AD-757 276

MONTANA LARGE APERTURE SEISMIC ARRAY

Robert E. Matkins

Philco-Ford Corporation

Prepared for:

Advanced Research Projects Agency

15 December 1972

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Technical Report 2056-72-28

MONTANA LARGE APERTURE SEISMIC ARRAY

FOURTH QUARTERLY TECHNICAL REPORT, PROJECT VT 2708

CONTRACT F33657-72-C-0390

1 SEPTEMBER 1972 - 30 NOVEMBER 1972

15 December 1972

SPONSORED BY

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NUCLEAR MONITORING RESEARCH OFFICE

ARPA ORDER NO. 1620

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PHILCO-FORD
COMMUNICATIONS & TECHNICAL SERVICES
DEFENSE SYSTEM SUPPORT ACTIVITY
214 North 30th Street
Billings, Montana

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Philco-Ford Corporation Communications and Technical Services Div. 214 North 30th, Billings, Montana 59101	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
	2b. GROUP N/A

3. REPORT TITLE
FOURTH QUARTERLY TECHNICAL REPORT
MONTANA LARGE APERTURE SEISMIC ARRAY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Technical, 1 September 1972 - 30 November 1972

5. AUTHOR(S) (First name, middle initial, last name)
Robert E. Matkins

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
15 December 1972	78	7

8a. CONTRACT OR GRANT NO. F33657-72-C-0390	9a. ORIGINATOR'S REPORT NUMBER(S) 2056-72-28
b. PROJECT NO. VELA T/2708	
c. ARPA Order No. 1620	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d. ARPA Program Code No. 2F10	

10. DISTRIBUTION STATEMENT

Approved for Public Release. Distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Details of illustrations in this document may be better studied on microfiche.	Advanced Research Projects Agency Nuclear Monitoring Research Office Arlington, Va.

13. ABSTRACT

This report relates the technical activity associated with the operation, maintenance, and improvement of the Montana Large Aperture Seismic Array (LASA) during the period 1 September - 30 November 1972. The short-period (SP) and long-period (LP) seismograph sensitivity performance statistics are [illegible]cated. Performance data on the SP seismometer, the SP high-level sensors, and the LP seismic amplifier are presented. Certain array surficial noise sources are identified. Development of a more comprehensive seismograph calibration technique for measurement of the amplitude and phase characteristics of the SP seismograph over a broad band of frequencies is reported. Progress with the installation of the SP channel CTH gain control modification is reported. Statistics relating to the operation and maintenance of the array and data center equipment and land facilities support are provided.

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
LASA - Large Aperture Seismic Array Seismic Array Seismic Observatory Operation Seismic Measurement Channel Performance Seismometers Seismic Amplifiers						

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IDENTIFICATION

AFTAC Project No.: VELA T/2708

Project Title: Montana Large Aperture Seismic Array

ARPA Order No.: 1620

ARPA Program Code No.: 2F10

Philco-Ford Corporation

Contract No.: F33657-72-C-0390

Effective Date: 1 December 1971

Amount of Contract: $1,200,627.00

Contract Expiration Date: 30 June 1973

Project Manager: B. G. Herrin, Phone No. (406)245-6332

NOTICE

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AVAILABILITY

Qualified users may request copies of this document from: Defense Documentation Center, Cameron Station, Alexandria, Va. 22314

ACKNOWLEDGEMENT

This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract No. F33657-72-C-0390.

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ACRONYMS

AFSC	Air Force Systems Command
ARPA	Advanced Research Projects Agency
CTH	Central Terminal Housing
DEC	Digital Equipment Corporation
IRSPS	Integrated Seismic Research Signal Processing System
LASA	Large Aperture Seismic Array
LASAPS	LASA Processing Subsystem
LDC	LASA Data Center
LMC	LASA Maintenance Center
LP	Long-Period
MDC	Maintenance Display Console
MET	Meteorological Equipment
MIT	Massachusetts Institute of Technology
MOPS	Multiple On-line Processing System
NOR-SAR	Norway Seismic Array
PDC	Power Distribution and Control
PLINS	Phone Line Input Systems
PMEL	Precision Measurement and Equipment Laboratory
PRBS	Pseudo-random Bit Sequences
SAAC	Seismic Array Analysis Center
SDL	Seismic Data Laboratory
SEM	Subarray Electronics Module
SP	Short-Period
VSC	VELA Seismological Center
WHV	Well Head Vault

SECTION I

INTRODUCTION

This report presents the accomplishments and administration of Contract Number F33657-72-C-0390. This contract between the Philco-Ford Corporation and AFSC Aeronautical Systems Division is for continued operation, research, and development of the Montana Large Aperture Seismic Array (LASA).

The LASA is part of the Vela Uniform Program which is sponsored by the Advanced Research Projects Agency (ARPA) of the Department of Defense. LASA is an experimental system consisting of many seismometers installed near Miles City, Montana, (Figure 1.1) used for the development of appropriate methods for the detection and identification of seismic events. Initially, the detection, location, and identification of seismic data were performed at the LASA Data Center (LDC) located at Billings, Montana. However, subsequent to implementation of the Integrated Seismic Research Signal Processing System (IRSPS), the array data is now transmitted to the Seismic Array Analysis Center (SAAC) in Alexandria, Va., for processing and analysis.

1.1 History

The LASA, installed in Eastern Montana during 1964 and 1965, is used for experiments in advanced seismological detection and discrimination. The initial installation, composed of 21 subarrays geometrically placed at a diameter of 200 kilometers with 525 short-period and 63 long-period seismometers, has evolved into the present array with the original 21 subarrays reduced to 346 short-period seismometers and 51 long-period seismometers.

Philco-Ford's participation in the Montana LASA began in 1964 by providing MIT Lincoln Laboratory with field engineering assistance. In June 1966, Philco-Ford assumed operational and maintenance responsibilities for MIT Lincoln Laboratory. On 1 May 1968, the project direction was transferred to the Electronics Systems Division, AFSC, with prime contracts to Philco-Ford through 30 November 1970.

On 1 December 1970, technical direction of the Montana LASA was assigned to the Vela Seismological Center (VSC). Under Projects V/T 1708 and V/T 2708 Philco-Ford continues the work of previous Montana LASA projects. This work basically involves the continued operation and maintenance of the array and data center systems, logistics and administrative support, data provision, and hardware evaluation and installation.

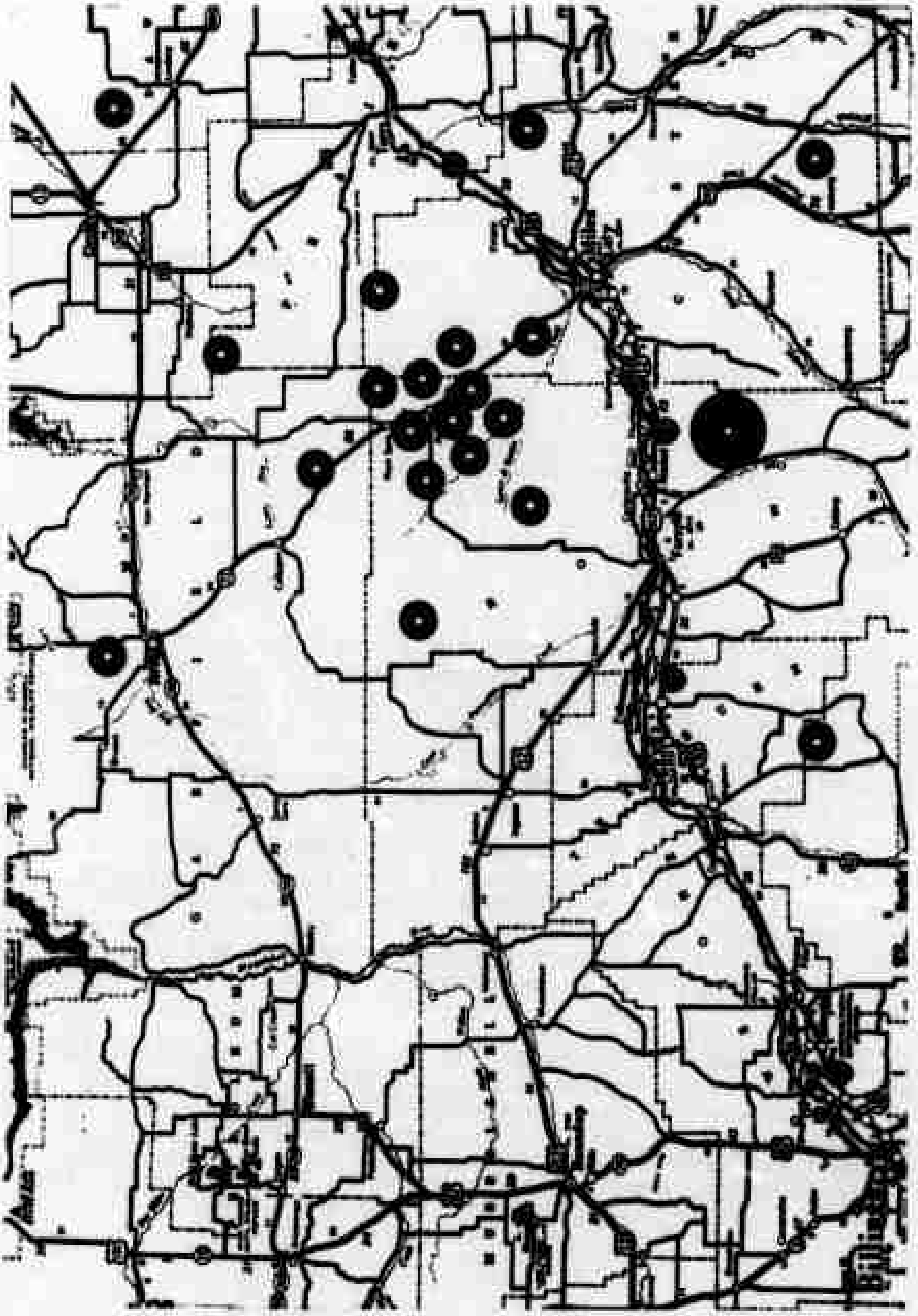


Figure 1.1 Montana LASA

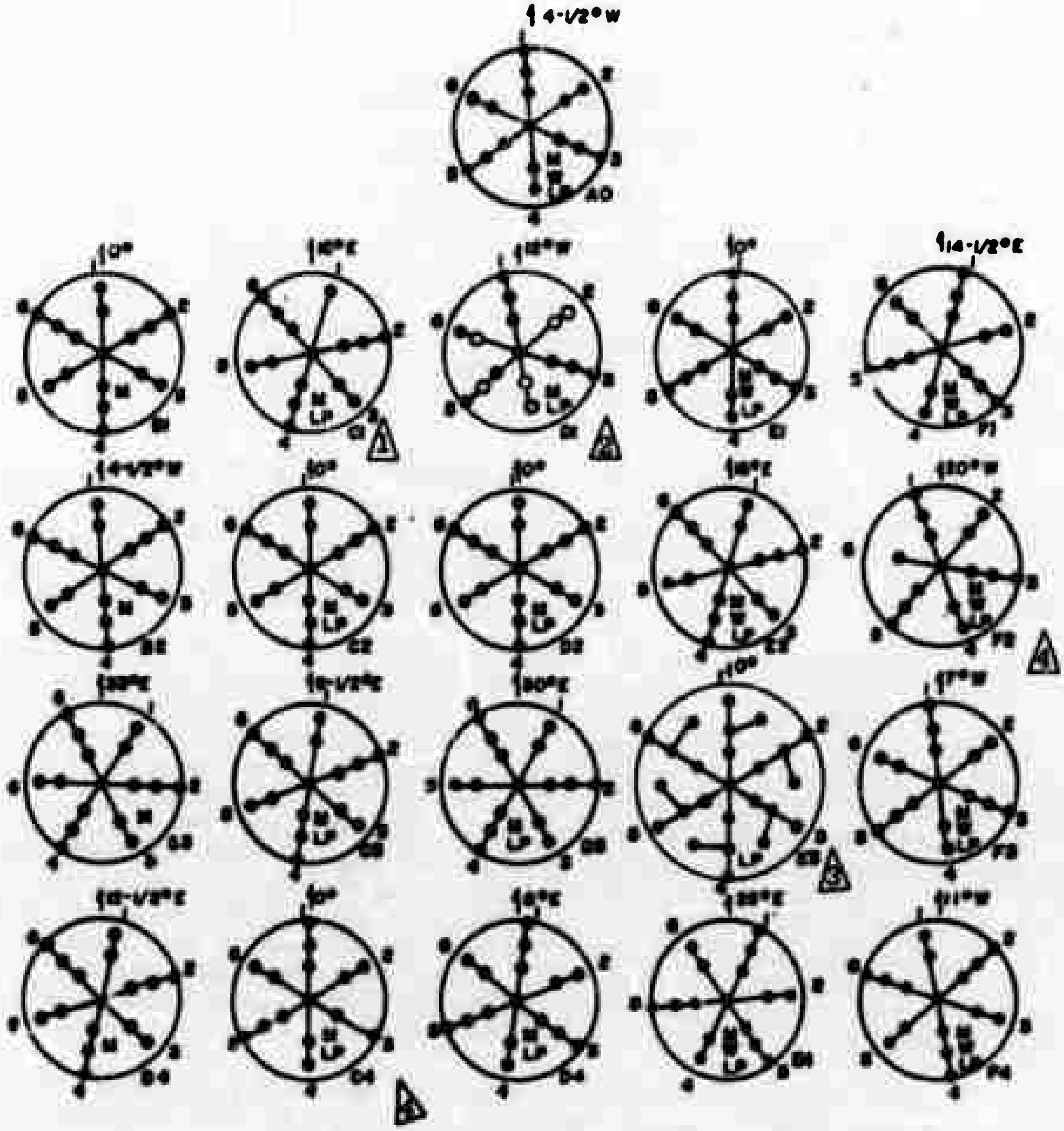
1.2 Description

The LASA with an overall diameter of 200 kilometers (124 miles) is composed of 21 subarrays arranged as shown in Figure 1.1. With the exception of subarray E3 which is 19 km in diameter, all subarrays are 7 km in diameter. Subarray E3 is configured with 25 short-period seismometers while others now have 16. All subarrays originally were designed with 25 seismometers each, however, programmed sensor removal has now lowered this number to 16 except at E3. The short-period seismometers are located along six radial cables which terminate in a central under-ground vault containing the Subarray Electronics Module (SEM). The subarrays also contain three-component long-period sensors, and weather sensors. Figure 1.2 shows the present configuration of each subarray.

The LDC controls the array operation by sending a command signal to each SEM at a rate of twenty times each second to cause sampling of the subarray signals. This command signal is suitably delayed at the LDC prior to transmission so that data from all SEMs will arrive at the LDC within predetermined time intervals.

The SEM responds to LDC timing system control signals with signal sampling, conversion, and transmission of all data to the LDC. Flexibility exists within the array in that the SEM can accomodate as many as 30 signal inputs; currently, signals from short and long-period seismometers, weather sensing equipment, and other measured parameters are telemetered. Signals from the 21 SEM's are transmitted to microwave junction points by open wire lines at a 19.2 kilobaud rate; from these points they are sent to the LDC by microwave radio facilities. At the LDC the data are processed and reformatted for transmission over a 50 kilobaud channel to SAAC. The LDC also contains the array timing and maintenance monitoring equipment. By means of telemetry commands, signal sources at the subarray are controlled to provide equipment calibrations and verify equipment performance.

The different LASA seismographs operating parameters and tolerances are identified in Tables I and II. Figure 1.3 shows the five different seismograph responses available.



▷ Notes
1. SP Sensors removed from leg 1 because of access difficulties
2. 0 denotes near surface SP sensors
3. Expanded subarray, 18 km diameter
4. SP sensor inoperative and lost in cased hole

All degrees shown are orientations with respect to true north. The letters LP, M, and W denote long period seismic, microbarograph, and weather sensors installed at the center of the subarray. Microbarograph data was not available for transmission to SAAC after March 24, 1972.

Figure 1.2 LASA Subarray Configurations

TABLE I

LASA SEISMOGRAPH OPERATING PARAMETERS AND TOLERANCES

CHANNEL IDENT.	OPERATING PARAMETERS AND TOLERANCES				
	T_s	λ_s	(MP_s)	S_{chan}	Full Scale Within
SPZ	1.0±0.1	0.7±0.1		20±3mV/nm@1.0s	609-823nm@1.0s
SPIZ	"	"		"	"
SPTZ	1.15	0.7		"	"
SPTN	1.06	"		"	"
SPTE	1.03	"		"	"
SPAZ	1.0±0.1	0.7±0.1		636±95mV/μm@1.0s	19.2-25.9μm@1.0s
LPZ	20.0±5%	0.77	0±1.5mm	350±50mV/μm@25s	35.0-46.7μm@25s
LPH	"	"	"	"	"
LPAZ	"	"	"	11±1.7mV/μm@25s	1102-1505μm@25s
LPAH	"	"	"	"	"
LPWZ	"	"	"	55±8.3mV/μm@25s	221-300μm@25s
LPWH	"	"	"	"	"
LEGEND:	T_s = Seismometer Free Period (Sec); λ_s = Seismometer Damping (MP_s) = Seismometer Mass Position from Center S_{chan} = Channel Sensitivity				

TABLE II

LASA SEISMOGRAPH CHANNEL IDENTIFICATION

CHANNEL	MANUFACTURER/MODEL	SEISMIC AMPLIFIER MFGR/MODEL	FILTER MFGR/MODEL/TYPE
SPZ	GeoSpace/HS-10-1A	Texas Inst./RA-5	4 pole ½dB ripple Chebyshev low pass, f_c=5.0 hertz, @10 hertz, -30dB.
SPAZ	GeoSpace/HS-10-1A	Texas Inst./RA-5	
SPIZ	GeoSpace/HS-10-1B	Ithaco/6072-65	"
SPTZ	Teledyne/TD-201D	Texas Inst./RA-5	"
SPTN	Teledyne/TD-201D	Texas Inst./RA-5	"
SPTE	Teledyne/TD-201D	Texas Inst./RA-5	"
LPZ	Geotech/7505A	Texas Inst./Type II	Texas Inst./Type II/Response A. 24 dB/oct high-cut, centered at 65 sec.
LPH	Geotech/8700C	Texas Inst./Type II	
LPAZ	Geotech/7505A	Texas Inst./Type II	"
LPAH	Geotech/8700C	Texas Inst./Type II	"
LPWZ	Geotech/7507A	Texas Inst./Type II	Texas Inst./Type II/Response C. 12 dB/oct high-cut, centered at approx. 100 sec.
LPWH	Geotech/8700C	Texas Inst./Type II	

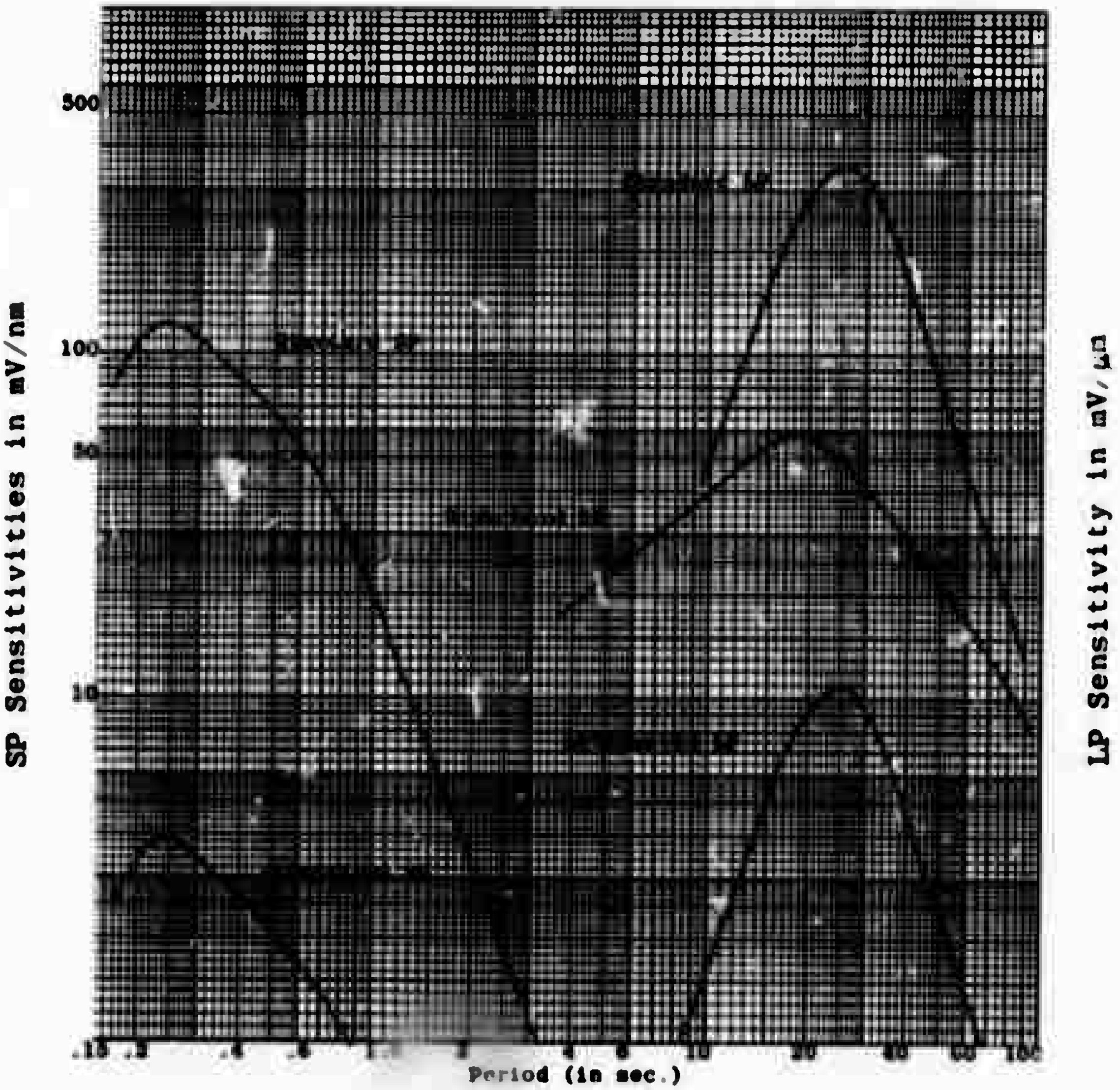


Figure 1.3 LASA Seismographs Response Curves

SECTION II

SUMMARY

Array operation, maintenance, and system improvement activities at the Montana LASA are all directed towards achieving an efficient seismic array operation. Operations support provided to the SAAC via the LDC computer totalled 96.0% for on-line data transmission and 4.0% for back-up recording during this period; for the contract the percentages are now 95.0 and 5.0 respectively.

Array monitoring and remote calibrations continue to reflect improvement in equipment performance resulting from improved maintenance practices. In addition to an improvement in the stability of the seismic channel characteristics, an increase in our understanding of the seismographs performance during seasonal variations has been gained from the analysis of calibration response data. The effort to reduce the natural frequency variation among the SP seismometers with a program of field measurements and instrument replacements has increased the percentage of frequencies within the ±10% tolerance to 89% of the 197 sensors tested to date. The array seismograph channel sensitivities averaged over the 91-day period were 20.6 mV/nm at 1s and 344 mV/μ m at 25s for the short and long-period channels respectively.

Completion of an improved calibration technique, utilizing the telemetry controlled pseudo-random bit sequences to generate a broadband of frequencies for input to the SP seismometers at each subarray, now provides a comprehensive amplitude and phase response measurement for each SP seismograph channel over the complete frequency range of interest. The calibration requires only a short interruption of selected subarray data (approx. 2½ minutes). PDP-7 program BASP performs a Fourier transform of the time-series calibration response data into the frequency domain. Processing with the present version of this program requires approximately one hour to complete the calculations for each seismograph channel.

Maintenance activity consisted primarily of SP subarray rehabilitations, installation of the SP channel CTH gain control modifications, and PDP-7 computer repairs.

SECTION III

OPERATION

3.1 General

Array operation is performed to provide data continuously from the array sensing and data acquisition systems to the LDC, to provide data on-line from the LDC to the SAAC, and to provide data recording in the event data transmission to SAAC is interrupted.

3.2 Data Center

The LASA Data Center (LDC) contains the equipment necessary to process the seismic array data either for transmission to SAAC or for recording locally. The activities in support of the LASAPS and other data center systems include: (1) IBM 360/44 computer operation on-line to SAAC, (2) PDP-7 computer operation to record array data in back-up of the 360 computer and to perform array monitoring, automatic calibrations, and off-line processing of array performance information, (3) maintenance display console operation for test and diagnosis of array equipment performance, (4) tape and film library operation for storage, handling, and shipment of array data recordings, (5) Develocorder operation for continuous recording of selected sensor channels for the Seismic Data Laboratory (SDL) and array quality control testing and analysis, and (6) telemetry link operation for continuous on-line data transmission of selected seismograph channels to MIT for data analysis.

3.2.1 SAAC/LDC Systems

Operation of the real-time data link between the SAAC and LDC so that a maximum amount of useful seismic data from the Montana array reaches SAAC for analysis is one of the main goals of our data center's operation. Monitoring of the SAAC/LDC operation during this quarterly period produced the operational statistics in Table III. Three operational modes which cause the outages shown are: (1) the SAAC computers are not available for LASAPS data acquisition, (2) the LDC Model 44 computer is not available for processing LASAPS data, and (3) the wideband communications channel between the LDC and SAAC is not in operation. These outage times are covered with digital recordings of the LASA data by the PDP-7 computer; however, no real time data is available at SAAC. Periods in which LASAPS data was not used in the IRSPS operation at SAAC totaled 86.5 hours so that for 96.04% of this reporting period the SAAC/LDC systems operated together. The wideband data link between the two centers was inoperative 12.7 hours or 0.58% of the period.

TABLE III

SAAC/LDC SYSTEM OPERATING TIMES

Sept. 72 - Nov. 72

	SEPT.	OCT.	NOV.	TOTAL
SAAC & LDC 360 On-Line	687.3	712.4	697.8	2097.5
SAAC Off-Line, LDC 360 Running				
PDP-7 Recording	27.6	23.0	14.7	65.3
360 Training	.0	.0	.0	.0
SAAC Up, LDC 360 Down, PDP-7 Recording				
Scheduled	2.7	1.7	3.7	8.1
Unscheduled	.4	.0	..0	.4
SAAC Up, Other Equipment Down, PDP-7 Recording				
Scheduled	.0	.0	.0	.0
Unscheduled	2.0	6.9	3.8	12.7
Totals (in hours)	720.0	744.0	720.0	2184.0

3.2.2 IBM/360 Model 44 Computer

The IBM/360 computer, the LASAPS data processor, was fully operational at the LDC for 99.61% of this quarter. The complete computer utilization statistics are given in Table IV. On-line processing time equalled 96.04% of the period. Maintenance activities used 8.1 hours or 0.37% of the available time.

3.2.3 DEC PDP-7 Computer

The DEC PDP-7 computer was fully operational for data center processing 94.8% of this quarter of which on-line processing accounted for 62.99%, and off-line 31.82%. The complete summary of computer utilization statistics are shown in Table V. The back-up operating mode of high-rate recording (Ref. 1) was required on 100 occasions covering an accumulated time period of 91.0 hours. During this operation 695 magnetic tapes were recorded by the computer on 56 of the 91 days of this reporting period. Low rate recordings totaling 715.3 hours were also made. Both low rate and high rate recordings are retained at the LDC for at least 30 days of recycle time prior to reuse.

3.2.4 Analog System

Two Geotech Model 4000 Develocorders are operated at the LDC. One is used to support data analysis work at SDL and the other to support array maintenance by providing a means to display various sensor outputs during different intervals of time. The SDL Develocorder is operated 24 hours a day and each film record is scanned in the film viewer to determine the quality of the film record and provide a log of occurrences which affect the quality and usability of the film record.

3.2.5 Tape/Film Library

The data center's library is used to store the PDP-7 computer magnetic tape recordings, the 360 computer disc recordings, and the Develocorder film recordings (prior to distribution) for reuse or reference. As of November 30, PDP-7 high-rate back-up recordings dating back to 5 September 1972 were in the library awaiting request or recycling. After releasing some tape previously saved for reference, the library of back-up recordings presently contains 720 tapes. During the period there were no tapes returned from SAAC and 60 faulty tapes were disposed of. A tape storage area has been established to hold the faulty tapes before final disposal is made because a use may still be possible for some tapes.

The library use statistics for this quarter are:

695 PDP-7 high rate tapes retained for recycling

120 IBM-360 tapes returned to SAAC

TABLE IV

SYSTEM/360 MODEL 44 COMPUTER UTILIZATION

Sept. 72 - Nov. 72

OPERATION	ACCUMULATED TIME, HOURS			
	SEPT.	OCT.	NOV.	TOTAL
On-line processing including:				
Fully operational with SAAC	687.3	712.4	697.8	2097.5
Running at LASA only	27.6	23.0	14.7	65.3
Down-time operating including:				
Scheduled maintenance	2.7	1.7	3.7	8.1
Corrective maintenance	.4	.0	.0	.4
Training	.0	.0	.0	.0
Shut down - 360 equipment	.0	.0	.0	.0
Shut down - Other equipment	1.2	6.9	3.8	11.9
Program halt or loop	.8	.0	.0	.8
Idle time	.0	.0	.0	.0
Totals	720.0	744.0	720.0	2184.0

TABLE V

PDP-7 COMPUTER UTILIZATION

Sept. 72 - Nov. 72

OPERATION	ACCUMULATED TIME, HOURS			
	SEPT.	OCT.	NOV.	TOTAL
On-line program operation including:				
Monitor & Weather Processing only	241.7	206.5	110.8	559.0
VLR Recording only	.0	.0	.0	.0
High Rate Recording only	34.1	28.2	21.3	83.6
Low Rate Recording only	262.4	349.7	103.2	715.3
VLR & High Rate Recording	.0	.0	.0	.0
VLR & Low Rate Recording	.0	10.3	.0	10.3
VLR & High & Low Rate Recording	.0	.0	.0	.0
High & Low Rate Recording	.1	4.9	2.4	7.4
Off-line program operation including:				
Tape Duplication & Verification	.0	.0	.0	.0
Data Analysis	7.9	.0	7.4	15.3
Utility Operation	6.8	6.5	406.7	420.0
Program Development	89.4	115.2	45.2	249.8
Diagnostic Programs & Testing	5.7	4.3	.0	10.0
Training	.0	.0	.0	.0
Down-time operation including:				
Scheduled Maintenance	.0	.0	3.5	3.5
Corrective Maintenance	64.8	10.6	14.4	89.8
Shut down PDP-7 Inoperative	5.8	1.8	1.3	8.9
Shut down - Other Equipment	.6	2.7	3.1	6.4
Program Halts	.7	3.0	.7	4.4
Idle	.0	.3	.0	.3
Totals	720.0	744.0	720.0	2184.0

550 PDP-7 low-rate format tapes retained for recycling

91 Develocorder film distributed to SAAC

3.3 Array

Array operation functions performed include (1) monitoring of all array systems to detect equipment and data degradations, (2) testing of all array systems to measure equipment performance characteristics, (3) interfacing with telephone company personnel to determine communications equipment performance, and (4) processing of array maintenance and operation data to obtain statistics and information for efficient array management. These tasks are performed utilizing the PDP-7 computer, the maintenance display console, and the Develocorders. The overall system quality control efforts are applied through these activities.

3.3.1 Monitoring

Array monitoring refers to the sensing of performance of the operational equipment through the measurement of equipment characteristics on an essentially continuous basis. At the LDC continuous monitoring of the array systems is accomplished using the built-in data monitors, viz. (1) the MDC alarm monitor panel, (2) the PDP-7 monitor program and (3) the 360 computer's on-line system. The MDC alarm monitor panel provides instantly both a visual and audible indication at the occurrence of either a data link failure between the LDC and a subarray or an alarm signal of subarray power and vault failures transmitted on telemetry word 31. The PDP-7 monitor program outputs each telemetry word 31 data change from any subarray and also prints out the duration of subarray data interruptions. The 360 computer's on-line system program periodically generates a variety of monitoring messages.

Operation and maintenance of the array equipment requires that the data be interrupted at various periods, during which time normal or reliable data may not be available to the LASA data user. The reasons established for data interruptions are: maintenance, either being performed or initiated; subarray equipment failure in which no maintenance has been initiated; telephone company(s) performing tests on the communication link not functioning; power outage at the subarray; or special data center testing. In the event any of these situations occur, a notation is made in the data interruption log relating to the data affected and the time period. For the case of short-period and long-period interruptions, SAAC is alerted via the System 360 typewriter. The total duration of data interruption reported for each subarray is broken down by month in Table VI.

3.3.2 Calibrations

Calibrations are performed from the data center to sense the performance of the operating array equipment through the

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES

SUB ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS (HOURS:MINUTES)			
		SEPT.	OCT.	NOV.	TOTALS
A0	SP	2:25	:05	0:0	2:30
	LP	2:25	:05	0:0	2:30
	Meteor	2:25	:05	0:0	2:30
	Telco	:50	0:0	0:0	:50
B1	SP	:49	16:04	3:20	20:13
	Telco	:54	0:0	0:0	:54
B2	SP	:42	0:0	5:37	6:19
	Telco	0:0	0:0	0:0	0:0
B3	SP	:50	:12	4:45	5:47
	Telco	:28	0:0	0:0	:28
B4	SP	0:0	0:0	3:26	3:26
	Telco	1:15	:14	2:46	4:15
C1	SP	1:09	9:21	4:05	14:35
	LP	1:09	9:21	4:05	14:35
	Telco	:41	0:0	0:0	:41
C2	SP	12:59	:17	5:30	18:46
	LP	16:44	:17	5:30	22:31
	Telco	:22	2:37	0:0	2:59
C3	SP	5:28	:16	2:16	8:00
	LP	5:28	:16	2:16	8:00
	Telco	:13	0:0	0:0	:13

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES (CONTINUED)

SUB ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS (HOURS:MINUTES)			
		SEPT.	OCT.	NOV.	TOTALS
C4	SP	0:0	1:02	0:0	1:02
	LP	0:0	1:02	0:0	1:02
	Telco	0:0	0:0	0:0	0:0
D1	SP	0:0	1:51	2:59	4:50
	LP	0:0	1:51	2:59	4:50
	Telco	1:01	0:0	0:0	1:01
D2	SP	:56	25:43	3:44	30:23
	LP	2:59	97:04	3:44	103:47
	Telco	:36	0:0	:29	1:05
D3	SP	1:06	:39	:12	1:57
	LP	1:06	:39	:12	1:57
	Telco	0:0	15:40	0:0	15:40
D4	SP	1:23	5:44	27:33	34:40
	LP	1:23	5:44	27:33	34:40
	Telco	0:0	0:0	0:0	0:0
E1	SP	24:18	1:34	:29	26:21
	LP	24:18	1:34	:29	26:21
	Meteor	24:18	1:34	:29	26:21
	Telco	0:0	0:0	0:0	0:0
E2	SP	:57	3:45	0:0	4:42
	LP	:57	3:45	0:0	4:42
	Meteor	:57	3:45	0:0	4:42
	Telco	5:12	0:0	:37	5:49

TABLE VI

SUBARRAY DATA INTERRUPTION OUTAGES (CONCLUDED)

SUB ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS (HOURS:MINUTES)			
		SEPT.	OCT.	NOV.	TOTALS
E3	SP	0:0	1:54	0:0	1:54
	LP	0:0	1:54	0:0	1:54
	Telco	:54	:13	0:0	1:07
E4	SP	:39	:50	:06	1:35
	LP	0:0	:50	:06	:56
	Meteor	0:0	:50	:06	:56
	Telco	:16	4:11	:25	4:52
F1	SP	:59	0:0	0:0	:59
	LP	:59	0:0	0:0	:59
	Meteor	:59	0:0	0:0	:59
	Telco	:36	0:0	:14	:50
F2	SP	5:46	3:36	:07	9:29
	LP	5:46	3:36	:07	9:29
	Meteor	5:46	3:36	:07	9:29
	Telco	1:52	0:0	:27	2:19
F3	SP	1:42	0:0	:09	1:51
	LP	1:42	0:0	:09	1:51
	Meteor	1:42	0:0	:09	1:51
	Telco	0:0	:13	0:0	:13
F4	SP	1:50	0:0	:14	2:04
	LP	1:50	0:0	:14	2:04
	Meteor	1:50	0:0	:14	2:04
	Telco	0:0	3:40	2:54	6:34

periodic measurement and/or adjustment of one or more equipment characteristics. Calibrations are performed daily for the short-period seismographs and weekly for the long-period systems. A set of telemetry remote controls (Ref. 2) connects the data center with each subarray and provides the means for determining the condition of the array equipment. The PDP-7 computer controls the application of the various telemetry command and calibration signals to the subarray(s), measures the signal responses, calculates the seismograph signal parameters, and outputs the data on punched paper tape for off-line printout. Program TESP is used for the short-period seismographs; program TELP for the long-period seismograph (Ref. 3). Normal channel responses to these sinusoidal calibrations are shown in Table VII, where A (volts) is the analog value, A (digital) is the digital value in decimal, and Y is the corresponding equivalent earth motion.

The remote measurement and adjustment of the long-period seismometer positioning is also performed weekly by the PDP-7 computer using the appropriate telemetry commands. Program MASPOS maintains each seismometer mass to within ± 1.4 mm from its center position. Similarly the seismometer natural frequencies are maintained to within 20 ± 1 seconds/cycle by program FREECK.

When the measured responses exceed the tolerances established for a particular channel, an equipment failure is reported to maintenance and to the users of the array data. The Defective Signal Channel Status Report is distributed each week to all agencies authorized by VSC. Table VIII indicates the incidence of defective channels detected during the three-month period for the three types of array data channels.

Further, for the interest of the array data user, precise times in which the array seismographs are interrupted for sinusoidal calibrations are reported here. These times are readily available from the PDP-7 computers MOPS on-line monitor program output and are indicated in Tables IX and X for the SP and LP sensors respectively. For the short-period calibrations only one calibration time is shown in Table IX for each week; the daily times are available upon request from the LDC. The equivalent earth motion of the calibration input signals to the seismometers are also shown in the two tables. Equivalent earth motion is determined from SEM channel 30 measurements during the calibration times. SEM channel 30 monitors the output of the sinusoidal oscillators which generate the signals applied to the seismometer.

Pseudo-random bit sequence calibration (see paragraph 5.2.1) of the SP array was performed on November 11 (day 316) for approximately 2½ minutes at each subarray starting at these times: AO, B and C-ring subarrays 2146:36 GMT, D and E-ring subarrays 2149:15 GMT, and F-ring subarrays 2151:53 GMT.

TABLE VII

LASA SEISMOGRAPH CALIBRATION RESPONSE TOLERANCES

CHANNEL IDENT.	TC	Peak-to-Peak Sinusoidal Amplitudes								
		A_{nom} Volts	A_{max} Volts	A_{min} Volts	A_{nom} Digital	A_{max} Digital	A_{min} Digital	Y_{nom}	Y_{max}	Y_{min}
SPZ	06[1]	7.91	9.09	6.72	9257	10638	7864	395nm	455nm	336nm
SPAZ	06[1]	.25	.289	.214	293	407	236	395nm	455nm	336nm
SPIZ	06[1]	7.91	9.09	6.72	9257	10638	7864	395nm	455nm	336nm
SPTZ	06[1]	7.91	9.09	6.72	9257	10638	7864	395nm	455nm	336nm
SPTN	06[1]	7.91	9.09	6.72	9257	10638	7864	395nm	455nm	336nm
SPTE	06[1]	7.91	9.09	6.72	9257	10638	7864	395nm	455nm	336nm
LPZ	20[2]	6.98	7.98	5.99	8168	9339	7010	20.0μm	22.8μm	17.1μm
LPH	20[2]	6.98	7.98	5.99	8168	93[illegible]	7010	20.0μm	22.8μm	17.1μm
LPAZ	20[3]	2.77	3.19	2.34	3242	3733	2738	252μm	290μm	213μm
LPAH	20[3]	2.77	3.19	2.34	3242	3733	2738	252μm	290μm	213μm
LPWZ	20[2]	1.10	1.26	0.93	1287	1475	1088	20.0μm	22.9μm	16.9μm
LPWH	20[2]	1.10	1.26	0.93	1287	1475	1088	20.0μm	22.9μm	16.9μm

Note 1. Amplitude measurements corrected for response to 400nm, 1s calibration signal.
2. Amplitude measurements corrected for response to 20μm, 25s calibration signal.
3. Amplitude measurements corrected for response to 222μm, 25s calibration signal.

TABLE VIII

INCIDENCE OF DEFECTIVE SUBARRAY CHANNELS

Sept. 1972 - Nov. 1972

SUBARRAY	CHANNELS		
	SP	LP	METEOR
A0	2	0 (9)	0
B1	3	-	-
B2	4	-	-
B3	4	-	-
B4	4	-	-
C1	0	0 (10)	-
C2	5	3 (11)	-
C3	1	0 (12)	-
C4	3	0 (7)	-
D1	1	1 (11)	-
D2	5	1 (22)	-
D3	3	1 (9)	-
D4	1	3 (20)	-
E1	1	0 (15)	0
E2	5	1 (7)	0
E3	6	0 (10)	-
E4	10	0 (12)	0
F1	8	0 (10)	0
F2	3	1 (19)	0
F3	1	1 (8)	0
F4	2	1 (9)	0
TOTALS	72	13 (201)	0

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS

SUBARRAY	Short-Period Array Sinusoidal Calibration Signal Start Times and Amplitudes										SUBARRAY
	Day 2.3 4 Sept 72		Day 255 11 Sept 72		Day 262 18 Sept. 72		Day 269 25 Sept 72		Day 276 2 Oct. 72		
	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	
A0	1511:20	385	1316:33	386	1342:35	387	1244:11	391	1604:32	396	A0
B1	1511:50	405	1317:03	404	1343:05	404	1244:41	404	1605:02	404	B1
B2	1512:20	403	1317:33	403	1343:35	405	1245:11	406	1605:32	408	B2
B3	1512:50	402	1318:03	402	1344:05	403	1245:41	406	1606:02	408	B3
B4	1513:20	415	1318:33	413	1344:35	413	1246:11	414	1606:32	411	B4
C1	1513:50	412	1319:03	413	1345:05	412	-	-	1607:02	414	C1
C2	1514:20	397	1319:33	398	1345:35	398	1247:11	400	1607:32	402	C2
C3	1514:50	404	1320:03	417	1346:05	417	1247:41	417	1608:02	418	C3
C4	1515:20	398	1320:33	400	1346:35	398	1248:11	401	1608:32	400	C4
D1	1515:50	406	1321:03	407	1347:05	408	1248:41	406	1609:02	406	D1
D2	1516:20	393	1321:33	393	1347:35	393	1249:11	392	1609:32	392	D2
D3	1516:50	413	1322:03	414	1348:05	414	1249:41	414	1610:02	412	D3
D4	1517:20	383	1322:33	385	1348:35	386	1250:11	391	1610:32	393	D4
E1	1517:50	401	-	-	1349:05	418	1250:41	418	1611:02	418	E1
E2	1518:20	404	1323:33	403	1349:35	403	1251:11	402	1611:32	402	E2
E3	1518:50	412	1324:03	410	1350:05	412	1251:41	410	1612:02	410	E3
E4	1519:20	408	1324:33	410	1350:35	410	1252:11	412	1612:32	412	E4
F1	1519:50	396	1325:03	393	1351:05	396	1252:41	398	1613:02	397	F1
F2	1520:20	408	1325:33	408	1351:35	408	1253:11	410	1613:32	410	F2
F3	1520:50	410	1326:03	411	1352:05	410	1253:41	405	1614:02	406	F3
F4	1521:20	364	1326:33	372	1352:35	376	1254:11	390	1614:32	363	F4

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Short-Period Array Sinusoidal Calibration Signal Start Times and Amplitudes										SUBARRAY
	Day 283 9 Oct. 72		Day 290 16 Oct. 72		Day 298 24 Oct. 72		Day 304 30 Oct. 72		Day 311 6 Nov. 72		
	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	
A0	1533:48	396	1426:59	397	1555:43	398	1451:03	401	1614:37	401	A0
B1	1534:18	404	1427:29	404	1556:13	401	1451:33	402	1615:07	402	B1
B2	1534:48	406	1427:59	410	1556:43	410	1452:03	410	1615:37	398	B2
B3	1535:18	406	1428:29	408	1557:13	413	1452:33	414	1616:07	412	B3
B4	1535:48	412	1428:59	410	1557:43	445	1453:03	428	1616:37	432	B4
C1	1536:18	414	-	-	1558:13	415	1453:33	415	1617:07	416	C1
C2	1536:48	403	1429:59	403	1558:43	403	1454:03	402	1617:37	402	C2
C3	1537:18	418	1430:29	418	1559:13	418	1454:33	418	1618:07	418	C3
C4	1537:48	401	1430:59	400	1559:43	397	1455:03	423	1618:37	425	C4
D1	1538:18	407	1431:29	408	1600:13	407	1455:33	405	1619:07	407	D1
D2	1538:48	391	1431:59	391	1600:43	391	1456:03	390	1619:37	390	D2
D3	1539:18	411	1432:29	363	1601:13	358	1456:33	410	1620:07	408	D3
D4	1539:48	394	1432:59	396	1601:43	401	1457:03	404	1620:37	404	D4
E1	1540:18	418	1433:29	417	1602:13	417	1457:33	416	1621:07	416	E1
E2	1540:48	401	1433:59	400	1602:43	398	1458:03	397	1621:37	397	E2
E3	1541:18	407	1434:29	410	1603:13	410	1458:33	407	1622:07	408	E3
E4	1541:48	412	1434:59	414	1603:43	414	1459:03	415	1622:37	414	E4
F1	1542:18	398	1435:29	397	1604:13	397	1459:33	401	1623:07	398	F1
F2	1542:48	411	1435:59	410	1604:43	410	1500:03	411	1623:37	410	F2
F3	1543:18	406	1436:29	407	1605:13	407	1500:33	410	1624:07	408	F3
F4	1543:48	363	1436:59	363	1605:43	363	-	-	1624:37	363	F4

TABLE IX

SP ARRAY SINUSOIDAL CALIBRATIONS (CONCLUDED)

SUBARRAY	Short-Period Array Sinusoidal Calibration Signal Start Times and Amplitudes						SUBARRAY
	Day 318 13 Nov. 72		Day 325 20 Nov. 72		Day 332 27 Nov. 72		
	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	Start Time (GMT)	P-P Ampl. nm	
A0	1508:17	403	1622:13	404	1446:32	405	A0
B1	1508:47	402	1622:43	402	1447:02	402	B1
B2	1509:17	398	1623:13	398	1447:32	398	B2
B3	1509:47	413	1623:43	413	1448:02	414	B3
B4	1510:17	397	1624:13	400	1448:32	403	B4
C1	1510:47	417	1624:43	417	1449:02	418	C1
C2	1511:17	403	1625:13	403	1449:32	403	C2
C3	1511:47	420	1625:43	420	1450:02	420	C3
C4	1512:17	425	1626:13	425	1450:32	426	C4
D1	1512:47	404	1626:43	406	1451:02	405	D1
D2	1513:17	388	1627:13	390	1451:32	390	D2
D3	1513:47	408	1627:43	397	1452:02	400	D3
D4	1514:17	408	1628:13	407	1452:32	410	D4
E1	1514:47	416	1628:43	416	1453:02	416	E1
E2	1515:17	396	1629:13	396	1453:32	395	E2
E3	1515:47	405	1629:43	406	1454:02	406	E3
E4	1516:17	413	1630:13	413	1454:32	415	E4
F1	1516:47	401	1630:43	401	1455:02	402	F1
F2	1517:17	410	1631:13	411	1455:32	410	F2
F3	1517:47	410	1631:43	411	1456:02	411	F3
F4	1518:17	362	1632:13	363	1456:32	362	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 248: 4 Sept 72			Day 255: 11 Sept 72			Day 262: 18 Sept 72			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. µm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. µm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. µm P-P	
A0	1537:39	1540:39	20.5	1730:10	1733:10	20.7	1807:18	1810:18	20.5	A0
C1	"	"	20.0	"	"	20.0	"	"	20.3	C1
C2	1545:39	1548:39	269	1738:10	1741:10	252	1815:18	1818:18	272	C2
C3	"	"	20.4	"	"	20.6	"	"	20.3	C3
C4	1553:40	1556:40	21.1	1746:10	1749:10	20.4	1823:18	1826:18	20.4	C4
D1	"	"	20.5	"	"	20.4	"	"	20.3	D1
D2	1601:40	1604:40	20.6	1754:10	1757:10	20.6	1831:18	1834:18	20.5	D2
D3	"	"	19.0	"	"	19.4	"	"	19.4	D3
D4	1609:40	1612:40	21.0	1802:10	1805:10	21.0	1839:18	1842:18	21.0	D4
E1	"	"	20.2	-	-	-	"	"	19.8	E1
E2	1617:40	1620:40	20.7	1810:10	1813:10	21.1	1847:19	1850:19	21.2	E2
E3	"	"	20.7	"	"	21.0	"	"	20.5	E3
E4	1625:40	1628:40	21.1	1818:10	1821:10	20.8	1855:19	1858:19	21.2	E4
F1	"	"	20.4	"	"	20.4	"	"	20.3	F1
F2	1633:40	1636:40	21.1	1826:11	1829:11	21.1	1903:19	1906:19	21.1	F2
F3	"	"	20.3	"	"	20.5	"	"	19.9	F3
F4	1641:40	1644:41	20.2	1834:11	1837:11	20.5	1911:19	1914:19	20.2	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 269: 25 Sept 72			Day 276: 2 Oct. 72			Day 283: 9 Oct. 72			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
A0	1625:17	1628:17	20.5	1753:17	1756:17	20.4	1547:10	1550:10	20.5	A0
C1	-	-	-	"	"	19.9	"	"	20.4	C1
C2	1633:17	1636:17	272	1801:17	1804:17	251	1555:10	1558:10	250	C2
C3	"	"	20.3	"	"	20.1	"	"	20.1	C3
C4	1641:17	1644:17	21.3	1809:17	1812:17	20.6	1603:10	1606:10	21.0	C4
D1	"	"	20.9	"	"	20.3	"	"	20.5	D1
D2	1649:17	1652:17	20.5	1817:17	1820:17	20.5	1611:10	1614:10	20.6	D2
D3	"	"	19.3	"	"	19.0	"	"	19.4	D3
D4	1657:17	1700:17	21.1	1825:17	1828:17	21.0	1619:10	1622:10	21.0	D4
E1	"	"	19.5	"	"	19.6	"	"	20.1	E1
E2	1705:18	1708:18	21.2	1833:17	1836:18	20.6	1627:11	1630:11	21.1	E2
E3	"	"	20.4	"	"	20.9	"	"	20.7	E3
E4	1713:18	1716:18	21.2	1841:18	1844:18	20.9	1635:11	1638:11	20.7	E4
F1	"	"	20.3	"	"	20.4	"	"	20.4	F1
F2	1721:18	1724:18	21.1	1849:18	1852:18	21.2	1643:11	1646:11	21.2	F2
F3	"	"	20.1	"	"	20.3	"	"	19.7	F3
F4	1729:18	1732:18	20.3	1857:18	1900:18	19.7	1651:11	1654:11	20.6	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude									SUBARRAY
	Day 290: 16 Oct. 72			Day 298: 24 Oct. 72			Day 305: 31 Oct. 72			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
A0	1517:39	1520:39	20.4	2120:32	2123:32	20.6	0151:13	0154:13	20.4	A0
C1	"	"	19.8	"	"	19.2	"	"	19.8	C1
C2	1525:39	1528:40	250	2128:32	2131:32	250	0159:13	0202:13	250	C2
C3	"	"	20.5	"	"	20.4	"	"	20.0	C3
C4	1533:40	1536:40	21.0	2136:32	2139:32	21.2	0207:14	0210:14	21.0	C4
D1	"	"	20.8	"	"	20.3	"	"	20.4	D1
D2	1541:40	1544:40	20.6	2144:33	2147:33	20.6	0215:14	0218:14	20.6	D2
D3	"	"	19.5	"	"	19.0	"	"	19.5	D3
D4	1549:40	1552:40	21.1	2152:33	2155:33	21.1	0223:14	0226:14	21.1	D4
E1	"	"	20.0	"	"	19.9	"	"	19.7	E1
E2	1557:40	1600:40	21.1	2200:33	2203:33	20.5	0231:14	0234:14	20.5	E2
E3	"	"	20.4	"	"	20.1	"	"	20.6	E3
E4	1605:40	1608:40	21.0	2208:33	2211:33	20.5	0239:14	0242:14	20.8	E4
F1	"	"	20.4	"	"	20.4	"	"	20.4	F1
F2	1613:40	1616:40	21.2	2216:33	2219:33	21.2	0247:14	0250:14	21.1	F2
F3	"	"	19.7	"	"	20.1	"	"	20.4	F3
F4	1621:41	1624:41	20.0	2224:33	2227:33	19.7	0255:14	0258:14	20.2	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONTINUED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude						SUBARRAY
	Day 311: 6 Nov. 72			Day 318: 13 Nov. 72			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
A0	1627:40	1630:40	20.3	1632:52	1635:52	20.4	A0
C1	"	"	19.1	"	"	19.2	C1
C2	1635:40	1638:40	249	1640:52	1643:52	249	C2
C3	"	"	20.2	"	"	19.9	C3
C4	1643:40	1646:40	21.2	1648:53	1651:53	20.4	C4
D1	"	"	21.0	"	"	20.4	D1
D2	1651:40	1654:40	20.7	1656:53	1659:53	20.6	D2
D3	"	"	19.2	"	"	19.5	D3
D4	1659:40	1702:40	21.1	1704:53	1707:53	21.1	D4
E1	"	"	19.5	"	"	20.1	E1
E2	1707:40	1710:40	21.3	1712:53	1715:53	20.9	E2
E3	"	"	20.3	"	"	20.0	E3
E4	1715:40	1718:40	20.4	1720:53	1723:53	21.2	E4
F1	"	"	20.4	"	"	20.4	F1
F2	1723:41	1726:41	21.1	1728:53	1731:53	21.2	F2
F3	"	"	20.1	"	"	20.3	F3
F4	1731:41	1734:41	19.8	1736:53	1739:53	20.3	F4

TABLE X

LP ARRAY SINUSOIDAL CALIBRATIONS (CONCLUDED)

SUBARRAY	Long-Period Array Sinusoidal Calibration Signal Times and Input Amplitude						SUBARRAY
	Day 325: 20 Nov. 72			Day 332: 27 Nov. 72			
	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	Start Time (GMT)	Stop Time (GMT)	Input Ampl. μm P-P	
A0	1832:45	1835:45	20.5	1726:27	1729:27	20.1	A0
C1	"	"	19.8	"	"	19.2	C1
C2	1840:45	1843:45	249	1734:27	1737:27	249	C2
C3	"	"	20.3	"	"	20.7	C3
C4	1848:45	1851:45	20.4	1742:27	1745:27	21.0	C4
D1	"	"	20.4	"	"	21.0	D1
D2	1856:45	1859:45	20.7	1750:27	1753:27	20.2	D2
D3	"	"	19.0	"	"	19.4	D3
D4	1904:45	1907:45	21.3	1758:27	1801:28	21.1	D4
E1	"	"	20.1	"	"	20.0	E1
E2	1912:46	1915:46	20.6	1806:28	1809:28	21.3	E2
E3	"	"	20.4	"	"	20.3	E3
E4	1920:46	1923:46	21.2	1814:28	1817:28	20.6	E4
F1	"	"	20.5	"	"	20.4	F1
F2	1928:46	1931:46	21.2	1822:28	1825:28	21.0	F2
F3	"	"	19.7	"	"	19.7	F3
F4	1936:46	1939:46	20.2	1830:28	1833:28	20.1	F4

3.3.3 Communications

The interface between array and data center provided by the communications systems plays an important part in the success of the array operation. Determination of data interruptions due to telephone circuit outages is one responsibility of the LDC operations activity. All outages reported by data center personnel are assigned a ticket number to aid in accounting for and identifying of the data interruption. Weekly meetings are held with the telephone company, viz., Mountain Bell and Mid-Rivers, personnel to review and describe all outages.

For the period between 1 September and 30 November 1972, the number and duration of array communications outages which exceeded a two hour duration were less than the previous quarter. The seven extended outages which totalled 35.0 hours are indicated in Table XI. Open wire troubles were the main cause for circuit outage.

TABLE XI

EXTENDED ARRAY DATA INTERRUPTIONS

DUE TO COMMUNICATIONS OUTAGES

DATE	DURATION	SITE	REASON FOR OUTAGE
09/08/72	4:39	E2	Telco Release for Maintenance
10/03/72	2:10	A0	No Trouble Found
10/15/72	4:11	E4	No Trouble Found
10/20/72	15:35	D3	Broken Open Wire
10/30/72	2:51	F4	Frost On Line
11/11/72	2:46	F4	Frost On Line
11/11/72	2:46	B4	Frost On Line

SECTION IV

ARRAY PERFORMANCE

4.1 Systems

The overall performance measure applied to each of the array's sensor systems is the array data availability. The percentage of time the array systems are on-line providing quality data determine the value of this measure. Data availabilities are calculated by combining the total subarray data interruption times shown in Table VI with the total sensor outage times reported on the Defective Signal Channel Status reports. The data availabilities compared with those of previous periods are as follows:

	4th Quarter	Previous 4th Quarter	Previous Contract
SP	94.56	97.0	96.7
LP	91.38	98.1	98.6
Met	99.72	99.8	99.2

Telephone circuit outages which affect all subarray systems are not included in the percentages. During this quarterly period the listed data availabilities were further reduced by 0.11% by the telco outages.

4.1.1 SP Seismograph

(a) Performance monitoring using program TESP

The performance monitoring from the sinusoidal calibrations of the 346 short-period seismograph channels during this three-month period has indicated an average channel sensitivity of 20.57 mV/nm at 1-second periods with an average standard deviation of 1.14 mV/nm. A summary of the test results obtained each week is shown in Table XII where the statistics are compared with those of the previous contract and those of the previous September - November period. The SP array maintenance programs continue to reflect increases in the amplitude stability of the SP seismographs. This is illustrated by the distribution of SP sensors within the ±15% sensitivity tolerance plotted in Figure 4.1. This figure shows the weekly percentage of sensors within the tolerance since 30 March 1970. The cyclic variation that occurs with the seasonal temperature changes continues to be apparent.

(b) Channel Stability

The individual channel stability of the SP seismograph is determined from a statistical sample of 86 sensors.

TABLE XII

SP ARRAY PERFORMANCE TESTING SENSITIVITY STATISTICS

DATE	NO. SENSORS	SENS. MEAN mV/nm	SENS. σ mV/nm	SENS. MAX. mV/nm	SENS. MIN. mV/nm	SENS. DEV. mV/nm
9/4	342	20.55	1.29	24.68	11.46	13.22
9/11	325	20.73	1.28	23.94	14.65	9.29
9/18	340	20.63	1.31	23.83	10.87	12.96
9/25	325	20.90	1.21	24.27	10.66	13.61
10/2	338	20.73	1.20	24.14	11.40	12.74
10/9	319	20.62	1.12	24.06	11.20	12.86
10/16	318	20.70	1.22	24.18	15.47	8.71
10/23	336	20.64	1.07	24.32	15.95	8.37
10/30	338	20.49	1.14	24.34	10.77	13.57
11/6	342	20.45	1.03	24.39	15.72	8.67
11/13	343	20.38	1.07	23.48	12.07	11.41
11/20	343	20.37	1.00	23.40	11.71	11.69
11/27	341	20.18	0.88	23.14	11.04	12.10
AVERAGE	334.62	20.57	1.14	24.01	12.54	11.52
PREVIOUS 4TH QTR. AVERAGE	342.0	20.48	1.36	24.02	16.03	8.32
CONTRACT AVERAGE	334.56	20.36	1.35	24.13	12.68	11.64
PREVIOUS CONTRACT AVERAGE	343.9	20.36	1.69	26.5	12.7	13.8

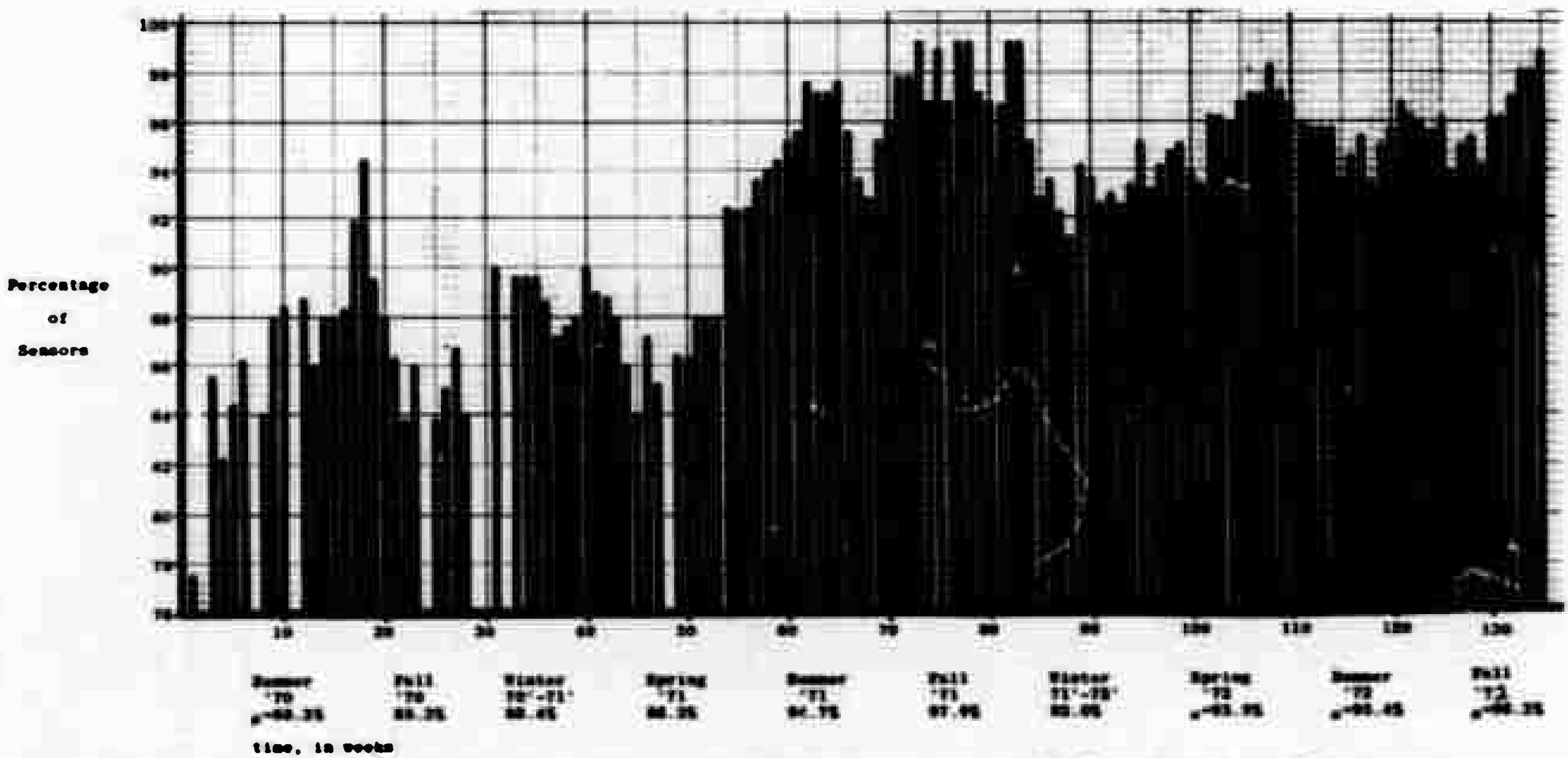


Figure 4.1 Percentage Distribution of SP Sensors in ±15% Sensitivity Tolerance

Six of these sensors were picked at random from subarray E3 and four were randomly sampled from each of the other 20 subarrays. Beginning 1 November 1971, the sensitivities of each of these 86 channels have been obtained from the daily printout of program TESP. At the end of each month a standard deviation of the sensitivity is calculated for each channel. This standard deviation is used as a comparative measure of individual channel stability. Table XIII summarizes this information.

Assuming the distribution of the sensitivity of an individual channel is normal or at least approximated by a normal distribution, Table XIII shows that in the large majority of cases the measured sensitivity can be expected to be within 1 mV/nm of the mean sensitivity.

During a month like September and March, when there are many flucuations in temperature and weather, and during a month like January when extreme temperatures are reached, the standard deviation of an individual channel is higher due to environmental stress on the RA-5 amplifiers. Therefore, during these months the channels whose standard deviation is near 0.333 mV/nm will generally be higher than 0.333 mV/nm. As a result the number of channels with standard deviation less than 0.333 mV/nm is lower than at other times. This is reflected in the last column of Table XIII. Those channels whose standard deviation is much greater than 0.333 mV/nm are generally channels that require adjustment or are failing, that is, the sensitivity is drifting consistently either up or down.

(c) Channel Frequency Response Measurement

SP channel frequency response measurement by subarray continued with the collection of response data from 46 sensors at three subarrays during this quarter. Figure 4.2 shows the mean, and the mean ± 3 standard deviations response curves of the array as measured during the period 19 May 1970 (B2) through 6 November 1972 (B1). The average age of the subarray data used in preparing these sensitivity plots is 10.5 months. The sensitivities are calculated using the measured values of output amplitude and sinusoidal input current amplitude and period, and the nominal values of calibration constant and seismic mass. Table XIV shows the average and the standard deviation of the channel sensitivities for each of the 16 frequencies used in the measurement. Individual plots are prepared to display the broadband response of each SP seismograph channel and to assist maintenance in determining channel malfunctions.

(d) Number of Sensors

A total of 366 SP seismograph channels originate from 346 individual seismometers installed at 344 sensor locations in the array. Twenty attenuated outputs and two horizontal component outputs are obtained from twenty-one locations to produce the 366 active channels. Twelve of the 346 seismometers vary from the configuration of the initial LASA installation. These are at

TABLE XIII

A DISTRIBUTION OF THE STANDARD DEVIATIONS OF 86 LASA SP CHANNELS

	MEAN S In mV/nm	MAXIMUM S In mV/nm	MINIMUM S In mV/nm	% <.3333 mV/nm
Nov. 71	0.1831	1.072	0.0570	95.3
Dec. 71	0.2236	1.945	0.0277	86.0
Jan. 72	0.2902	1.306	0.0807	73.3
Feb. 72	0.2559	1.690	0.0630	80.2
Mar. 72	0.3075	2.050	0.0849	70.6
Apr. 72	0.2030	3.007	0.0415	93.0
May 72	0.2629	1.025	0.0625	79.1
Jun. 72	0.2190	1.582	0.0370	91.9
Jul. 72	0.2613	1.348	0.0640	83.7
Aug. 72	0.2335	0.7292	0.0372	90.7
Sep. 72	0.3022	0.9937	0.0809	73.3

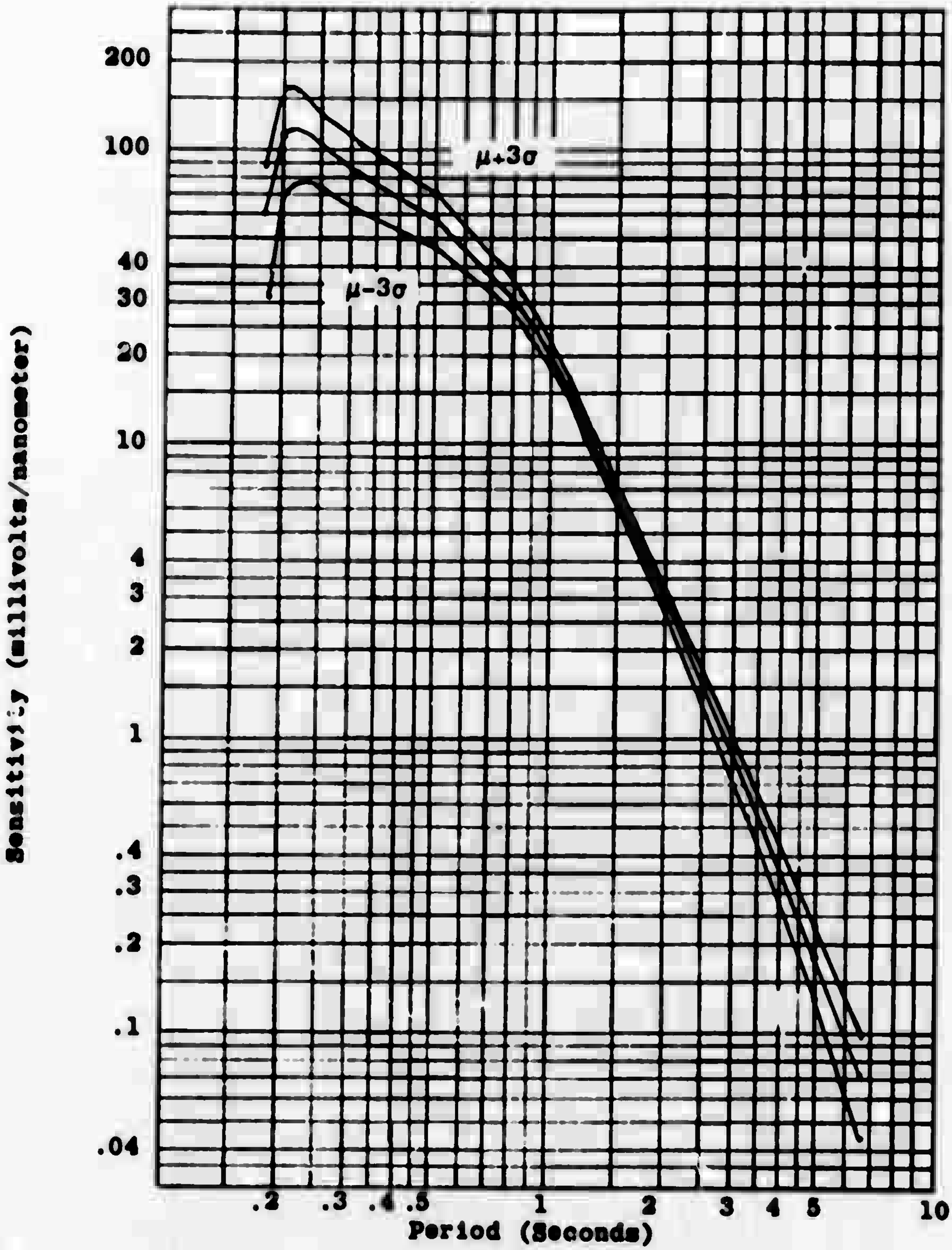


Figure 4.2 LASA SP Sensor Period vs Sensitivity Response Curves

TABLE XIV

SEISMOGRAPH FREQUENCY RESPONSE OF SP ARRAY

FREQUENCY (HERTZ)	SEISMOGRAPH CHANNEL SENSITIVITY (MV/NM) NO. CHANNELS - 337		
	MEAN	STANDARD DEVIATION	MAXIMUM DEVIATION
0.15	0.071	0.009	0.034
0.20	0.184	0.017	0.067
0.30	0.659	0.037	0.135
0.50	3.07	0.116	0.460
0.70	7.99	0.253	1.07
0.80	11.5	0.38	1.40
0.90	15.6	0.50	1.70
1.0	19.8	0.69	2.50
1.1	24.3	0.90	3.30
1.2	28.7	1.17	4.50
1.3	32.9	1.47	6.00
2.0	59.5	3.87	17.0
3.0	82.4	7.11	31.9
4.0	104.0	9.8	39.2
5.0	118.0	16.6	59.1
6.0	60.3	9.76	35.7

subarray D2 where three channels are derived from a TD-202 triaxial seismometer in hole 10, and three channels are from high-level combination seismometer-amplifier sensors at holes 62, 23, and 46 and at subarray D1 where six channels originate in near-surface seismometers at holes 52, 72, 54, 74, 65, and 56.

4.1.2 LP Seismograph

(a) Performance Monitoring Use Program TELP

The performance monitoring of the 45 standard LASA LP long-period sensors continued during the period following the procedures of the previous quarter. A channel sensitivity average of 344.10 mV/μm at 25s and a standard deviation of 20.19 mV/μm are reported from these seismographs for the three month period. The weekly test results obtained are shown in Table XV where this quarter's statistics are summarized and compared with those of the previous September - November period.

Plotted in Figure 4.3 is the percentage distribution of the LP sensors within the 350 ± 50 mV/μm sensitivity tolerance throughout the 24 month period starting 8 December 1970 through 27 November 1972.

(b) Channel Stability

To determine the channel stability of the LP seismograph the 45 channels of the 15 standard LASA-LP sensors are being studied individually. Shown in Table XVI are the sensitivity statistics of the data collected each week of the 56-week period from 1 November 1971 through 30 November 1972. The standard deviation of the channel sensitivity is used to measure the week-to week variation or stability of the channel output to electromagnetic calibration. The average of the 45 standard deviations calculated for the period is 16.80 mV/μm or 16.8% of the ± 50 mV/μm tolerance. The best performance was obtained from the vertical channel of the F3 LP seismograph with a 7.44 mV/μm standard deviation. The vertical channel at subarray F1 had a sensitivity standard deviation of 35.35 mV/μm for the poorest performance.

4.2 Equipment

The equipment within the array systems are being evaluated on a continuing basis to identify their individual performance characteristics, to detect signs of aging, and to improve methods of detecting malfunctions. Progress of these evaluation efforts is reported in this section as information is collected and/or analyzed and made available for publication. In this report the SP seismometer, the SP high-level sensors, and LP seismic amplifier evaluations are discussed.

TABLE XV

LP ARRAY PERFORMANCE TESTING SENSITIVITY STATISTICS

DATE	NO. SENSORS	SENS. MEAN mV/µm	SENS. σ mV/µm	SENS. MAX. mV/µm	SENS. MIN. mV/µm	SENS. DEV. mV/µm
9/4	45	339.98	18.42	401.39	303.42	97.97
9/11	42	336.33	17.77	375.02	297.93	77.09
9/18	44	334.77	20.44	380.11	266.82	113.29
9/25	44	337.59	23.17	400.14	275.55	124.59
10/2	45	340.38	22.92	407.33	281.09	126.24
10/9	43	341.44	24.38	411.82	280.84	130.98
10/16	44	345.46	21.43	413.78	307.70	106.08
10/23	45	344.37	16.99	377.98	307.35	70.63
10/30	45	345.82	17.76	372.83	300.53	72.30
11/6	44	347.55	17.39	375.39	314.17	61.22
11/13	45	352.64	19.53	418.19	313.04	105.15
11/20	45	352.73	20.04	397.54	303.62	93.92
11/27	44	354.28	22.29	429.89	305.95	123.94
AVERAGE	44.23	344.10	20.19	391.49	296.77	100.26
PREVIOUS 4TH QTR. AVERAGE	44.0	351.2	18.0	397	310	87
CONTRACT AVERAGE	44.49	352.38	17.55	397.04	306.14	92.30
PREVIOUS CONTRACT AVERAGE	44.6	356.1	18.8	403	312	90

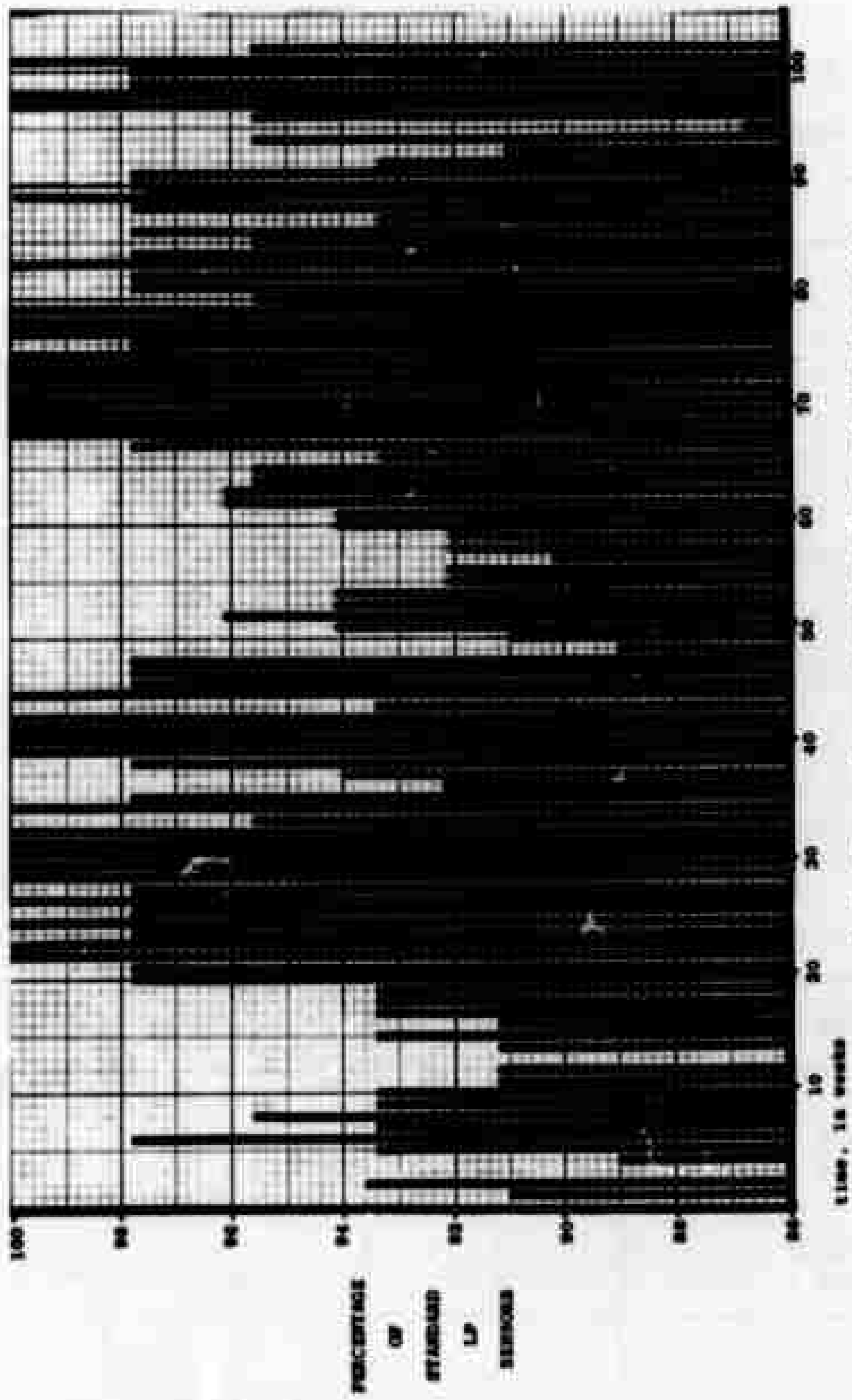


Figure 4.3 Percentage Distribution of LP Sensors within ± 50 mV/µm Sensitivity Tolerance

TABLE XVI

LP CHANNEL SENSITIVITY STATISTICS, NOV '71 THRU NOV '72

(All channels except C1 and C2)

LP CHANNEL	CHANNEL SENSITIVITY IN mv/μm AT 25 SECOND PERIODS				
	MEAN	STD DEV	MAXIMUM	MINIMUM	MAXIMUM DEV
A0-V	350.47	25.38	426.82	315.17	111.65
A0-N/S	357.02	24.55	407.42	316.42	90.67
A0-E/W	342.16	16.07	369.42	309.74	59.68
C3-V	356.02	10.52	373.58	334.02	39.56
C3-N/S	376.68	13.35	424.68	349.68	75.43
C3-E/W	347.21	23.32	382.07	308.63	73.44
C4-V	349.02	14.15	375.94	316.94	59.00
C4-N/S	348.26	15.78	411.02	320.21	90.81
C4-E/W	341.31	18.86	397.36	319.28	78.08
D1-V	355.92	10.43	380.24	337.52	42.72
D1-N/S	346.86	16.57	376.15	280.84	95.31
D1-E/W	350.78	16.05	377.10	323.24	53.86
D2-V	334.61	23.48	378.53	303.62	74.91
D2-N/S	338.13	28.65	400.04	266.82	133.22
D2-E/W	325.47	17.40	370.06	298.43	71.63
D3-V	360.70	13.90	401.47	338.76	62.71
D3-N/S	353.81	11.54	375.07	330.63	44.44
D3-E/W	359.16	9.94	380.79	333.24	47.55
D4-V	355.89	13.39	373.46	314.10	59.36
D4-N/S	372.12	11.43	392.69	350.65	42.04
D4-E/W	363.24	18.83	413.78	331.74	82.04
E1-V	363.14	20.15	405.01	328.80	76.21
E1-N/S	340.41	16.94	365.37	309.63	55.74

TABLE XVI

LP CHANNEL SENSITIVITY STATISTICS, NOV '71 THRU NOV '72
(CONCLUDED)

(All channels except C1 and C2)

LP CHANNEL	CHANNEL SENSITIVITY IN mv/μm AT 25 SECOND PERIODS				
	MEAN	STD DEV	MAXIMUM	MIMIMUM	MAXIMUM DEV
E1-E/W	344.14	19.99	374.65	300.58	74.07
E2-V	344.18	7.70	356.61	330.03	26.58
E2-N/S	360.61	11.46	378.71	338.47	40.24
E2-E/W	380.91	17.40	429.89	344.32	85.57
E3-V	365.71	14.68	388.11	336.64	51.47
E3-N/S	370.87	13.83	391.55	346.75	44.80
E3-E/W	369.21	34.12	420.61	321.34	99.27
E4-V	340.65	10.47	368.58	310.42	58.16
E4-N/S	349.65	8.51	365.17	332.11	33.06
E4-E/W	351.95	14.71	384.70	319.03	65.67
F1-V	351.93	35.31	423.08	285.43	137.65
F1-N/S	355.88	19.51	394.11	311.69	72.42
F1-E/W	361.27	26.66	411.70	324.14	87.56
F2-V	356.02	12.42	373.24	306.41	66.83
F2-N/S	352.60	17.47	378.95	323.77	55.18
F2-E/W	360.79	14.36	380.43	288.52	91.91
F3-V	353.66	7.44	373.29	341.75	31.54
F3-N/S	344.10	9.40	364.31	326.08	38.23
F3-E/W	363.82	15.77	379.86	280.44	99.42
F4-V	331.09	19.40	352.47	231.63	120.84
F4-N/S	335.97	20.18	364.80	293.79	71.01
F4-E/W	348.35	14.37	372.77	324.12	48.65

4.2.1 SP Seismometer, HS-10-1/A

With the completion of the SP subarray rehabilitation program for the season, the array's SP seismometer natural frequencies have been improved and are better identified. Seismometer natural frequency measurements were made at 24 sensor locations during this quarter to bring the total for the season to 99. The natural frequency data collected have been combined with others collected during this measurement program to produce the frequency distribution shown in Figure 4.4. For comparison, Figure 4.5 shows the frequency distribution at the start of this year's rehabilitation program. The recent plot now covers 197 or 56.9% of the array's seismometers or a 25% increase over the number of measurement data previously available.

The tolerance allowed is ±10% so that all seismometer's natural frequencies measuring 1.0 ± 0.1 hertz are considered to be operating satisfactorily. Seismometer replacements and field corrections, that is, repositioning the seismometer in the casing, has increased the estimated percentage of natural frequencies now inside the tolerance limits from 69.9 to 88.8%. Of the 197 seismometers tested, 22 are presently operating outside the allowable natural frequency range; three of these are stuck at the bottom of the well casings and can't be corrected. Figure 4.6 indicates the natural frequency status of each seismometer data channel in the array.

Seismometer damping measurement data have been collected from 127 sensors. The frequency distribution of these data from 36.7% of the array's SP sensors, plotted in Figure 4.7, indicates the seismometers are somewhat underdamped from the nominal 0.7 damping ratio.

4.2.2 SP High-Level Sensors

At holes 23 and 62 of subarray D2 are two Ithaco/GeoSpace high level seismometers each consisting of an Ithaco Model 6072-65A preamplifier and a GeoSpace HS-10-1B seismometer. These two sensors were installed at hole 23 on 5 October 1967 and at hole on 13 May 1968 (Ref. 4). Later a GeoSpace HS-10-1A seismometer and a Texas Instrument RA-5 amplifier were modified so that the amplifier is down the hole in a modified case with the seismometer and installed at hole 46 of subarray D2.

To determine the effectiveness of the down hole amplifier, as opposed to the standard RA-5 amplifier, during the seasonal changes and environmental stresses in the LASA array, the sensitivity of each channel of subarray D2 was recorded from the daily TESP printout beginning 1 November 1971 and ending 31 August 1972. Table XVII is a distribution of the statistical parameters of the channel sensitivity of each of these channels. Using the standard deviation as a measure of how stable a channel is, Table XVII shows that the two Ithaco/GeoSpace seismometers are most stable while

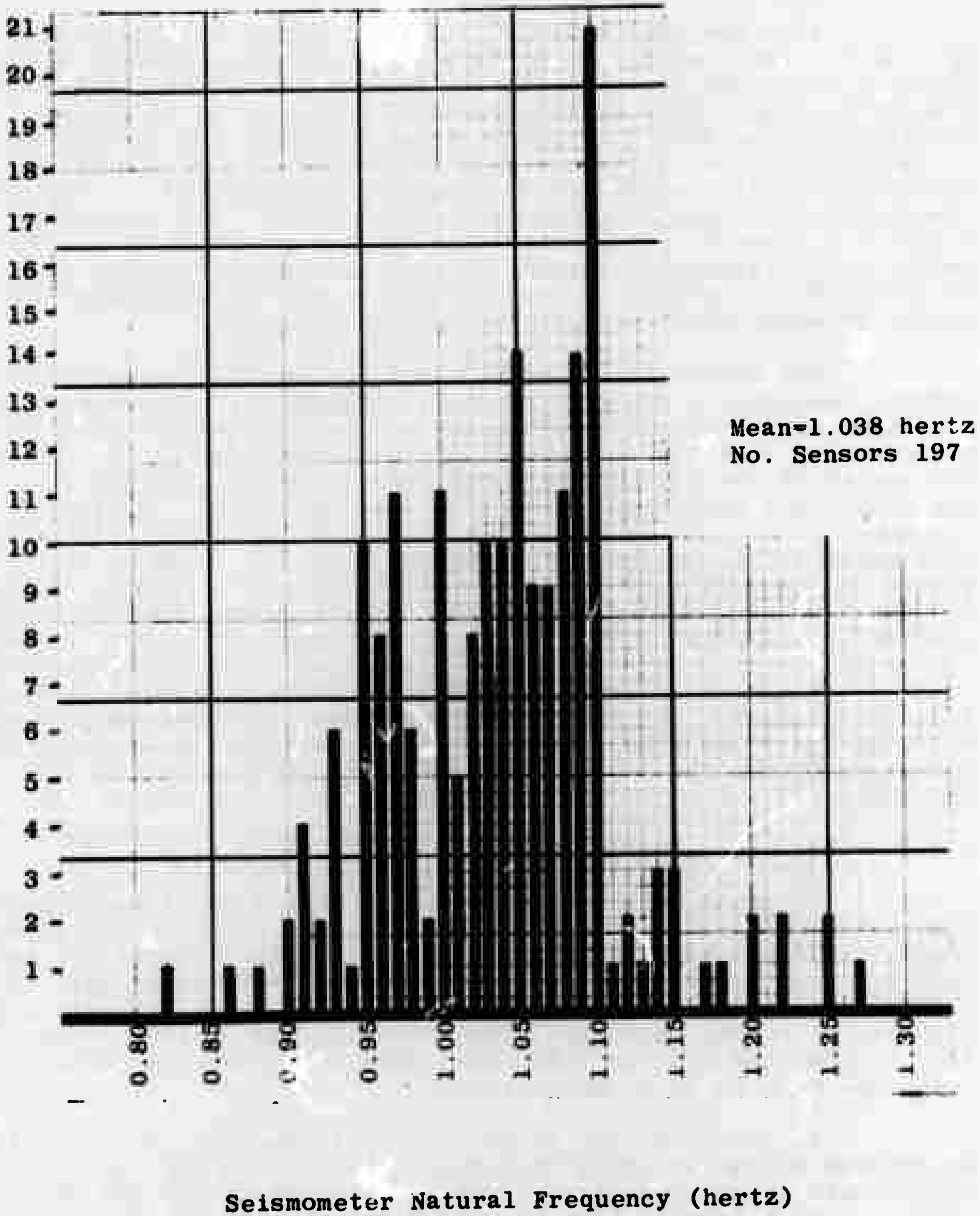


Figure 4.4 SP Seismometer Natural Frequency Distribution, 1970-1972

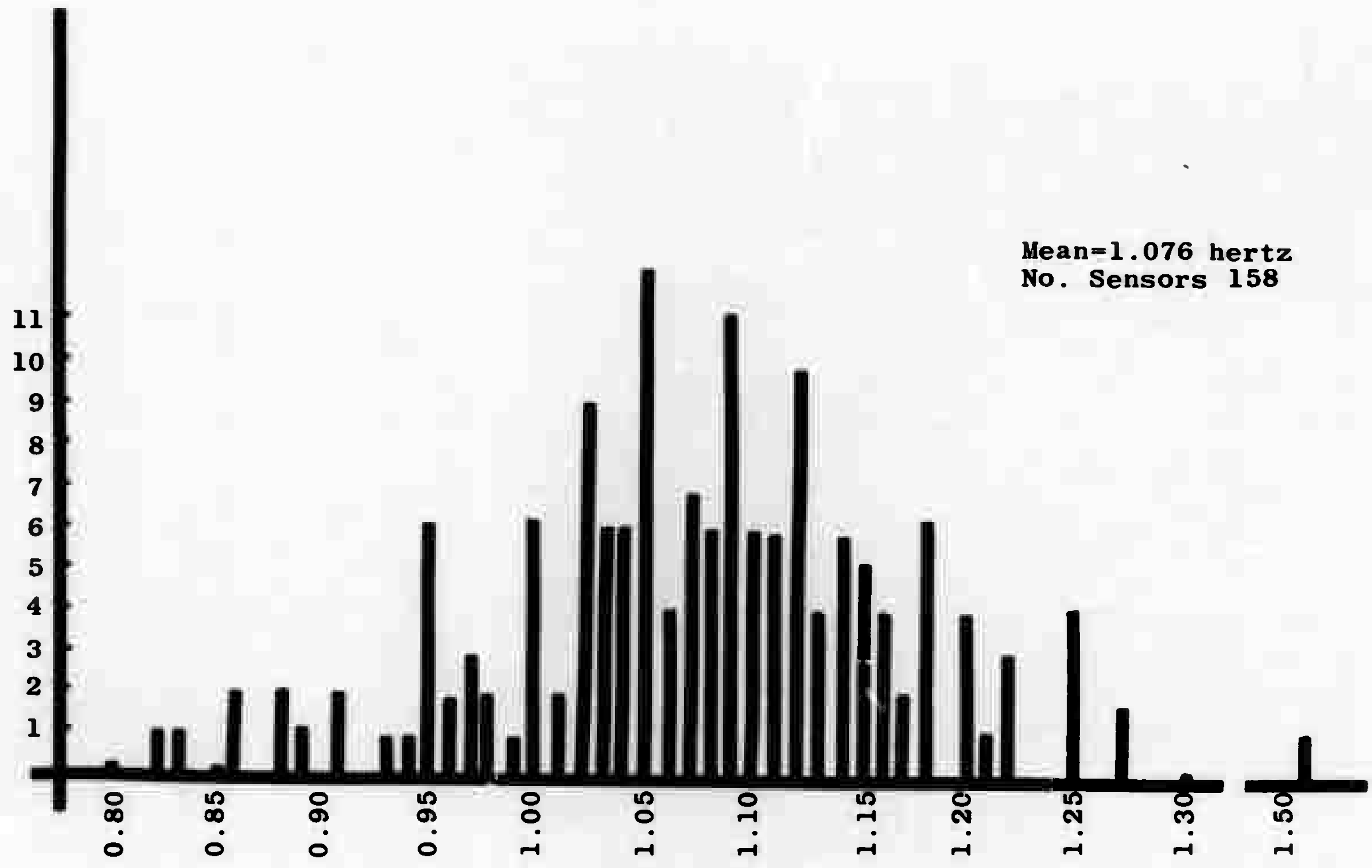


Figure 4.5 SP Seismometer Natural Frequency Distribution, 1970-71

Figure 4.6

Seismometer Natural Frequency Status of Array

Data Channel Number	Subarrays																			
	A 0	B 1	B 2	B 3	B 4	C 1	C 2	C 3	C 4	D 1	D 2	D 3	D 4	E 1	E 2	E 3	E 4	F 1	F 2	F 3	F 4
1	O	O		O		O	O	O	O	O		O		O	O		O		O	O	O
2	W	E	E	E	E	E	E	E	E	E		E	E	W	W		W	W	W	W	W
3	O	E	E	E	E	E	E	E	O	X		E	O	O	E		O		O	O	E
4	O	O		O	X	E	O	O	O						O		O				X
5							O	O				O									O
6	W	E	E	E	E	E	E	E	E	E	E	E	E	W	W		W	W	W	W	W
7	E	O	O	X	X	O	O	O	E	E	O	O	E	E	O		E	E	E	E	
8				O		O	O	O	O			O		O	O		O		O	O	
9	O	O			O		O	O		O				O					O	O	O
10	W	E	E	E	E	E	E	E	E	E		E	E	W	W		W	W	W	W	W
11	O	E	E	E	E	E	E	E	O	X		E			E		O	X	O	O	E
12		O	X		X	O	O		E			O	O	O			O		O		O
13			X		X		O	O	O	O	O	O	O	O	O		O		O	O	O
14	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	E
15	W		X	O		O	O	O	E	E	O		E	E			E	E	E	E	O
16	O		O		O		O		O	O		O	O		O		O	O	O		O
17		O	O	O			O	O	O	O		O			O		O	O	O	O	O
18	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	E
19	O	E	E	E	E	E	E	E		O	E	E		X	E		O	O	O	O	E
20	O				X		O		O	O	X	O		X	O		O		O	O	
21	O			O	O		O	O	O	X	O	O		O	O		O	O	O		
22	O	O		O		O	O	O	O	O		O		O	O		O		O	O	O
23	E	O		O	X			X	E	E			E	E			E	E	E	W	O
24	O	O		X			O	X	O	O	O		O						O	O	O
25	O	O	X		O	O	O	O			O		O	O				O	E		O

Legend: 0 - Natural frequency within 1 ± .1 hertz

X - Natural frequency exceeds 1 ± .1 hertz

E - Empty data channel, no sensor connected

W - Weather Instrumentation Data Channel

Blank - Natural frequency measurement data not current

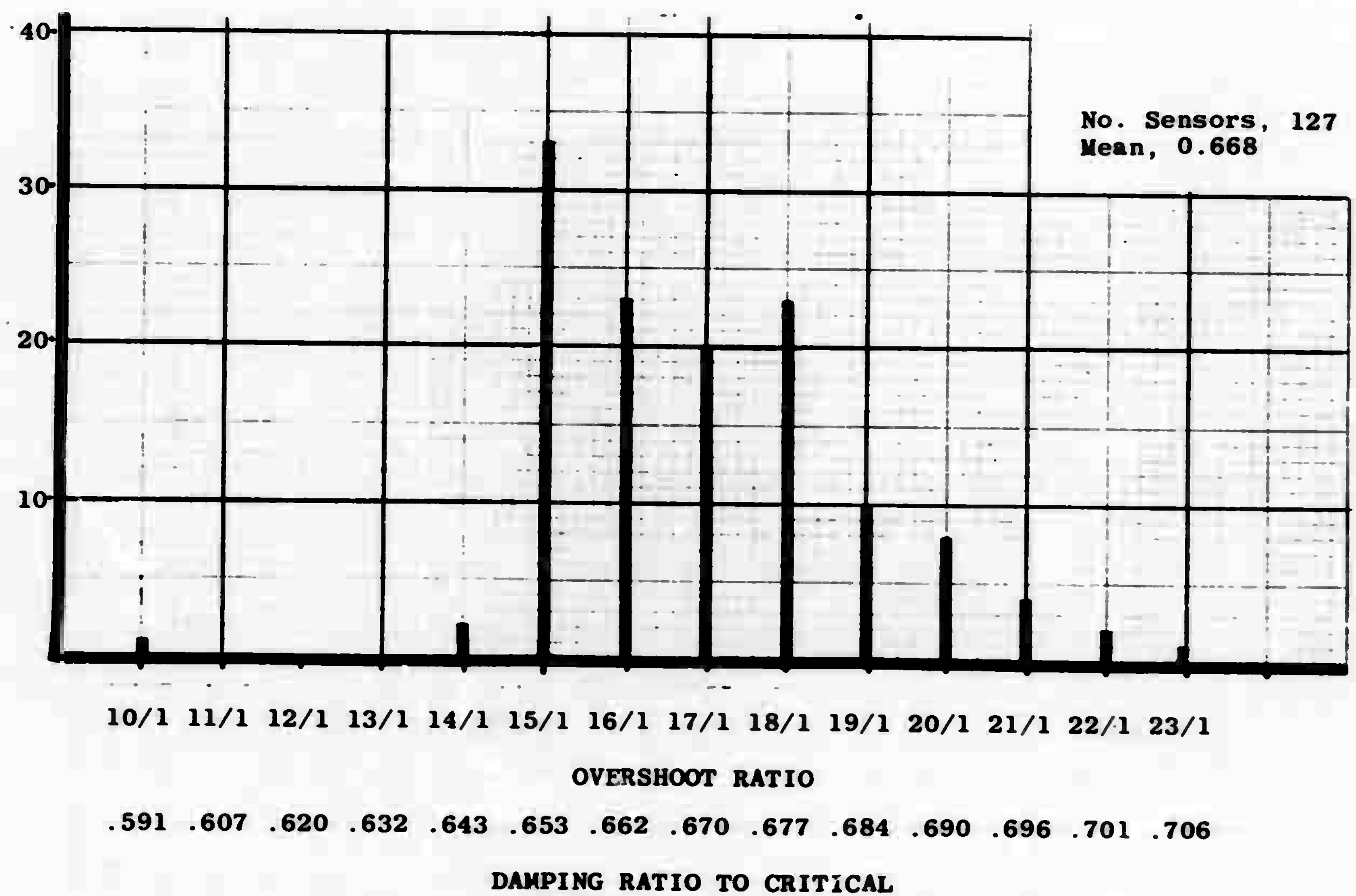


Figure 4.7 SP Seismometer Damping Ratio Distribution, 1972

TABLE XVII

DISTRIBUTION OF THE SUBARRAY D2 SP SEISMOGRAPH CHANNEL SENSITIVITIES IN mV/nm AT 1 SECOND DURING THE PERIOD 1 NOV. 71 - 31 AUG. 72

SENSOR	STANDARD DEVIATION	MEAN	MAXIMUM	MINIMUM	MAXIMUM DEVIATION
D2-23	0.19336	21.22	21.55	20.68	0.87
D2-62	0.20435	22.17	22.94	21.57	1.37
D2-46	0.23399	21.07	21.52	20.44	1.08
D2-66	0.29434	20.19	20.86	19.55	1.31
D2-82	0.34332	18.49	19.73	17.70	2.03
D2-10V	0.37457	18.34	19.15	17.41	1.74
D2-42	0.39926	22.04	22.91	21.07	1.84
D2-44	0.44921	19.20	20.19	18.45	1.74
D2-75	0.45082	21.09	22.02	20.02	2.00
D2-73	0.49018	20.23	21.55	19.21	2.34
D2-86	0.51332	19.77	20.87	18.71	2.16
D2-53	0.54824	20.90	22.14	19.26	2.88
D2-10N/S	0.59455	20.74	21.77	19.24	2.53
D2-71	0.65211	20.21	21.26	18.28	2.98
D2-55	0.74845	21.10	21.97	19.04	2.93
D2-26	0.78651	19.83	21.04	18.16	2.88
D2-84	0.80111	21.01	21.86	19.15	2.71
D2-64	1.25686	19.41	21.14	15.89	5.25
D2-51	1.34146	18.59	22.01	17.62	4.39
D2-10E/W	2.57339	17.36	21.24	9.59	11.65

the modified down hole RA-5 is third. This greater degree of stability (more than 200% better than the subarray average) is atributed to the stable environment at the bottom of the 200-foot holes. The seasonal temperature changes have little or no effect on the sensitivity of these down hole amplifiers. The standard RA-5 amplifiers are affected by the extreme seasonal temperature changes.

Further, since the installation of these three down hole amplifiers there have been no failures reported for any one of the three. Considering the length of time these channels have been in operation and the SP channel failure rate it appears the more stable environment of the down hole amplifiers reduces the need for maintenance.

4.2.3 LP Seismic Amplifier, Type II

The gain of the LP seismic amplifier at 0.04 hertz is measured remotely each week from the LDC under control of PDP-7 program TELP (Ref. 3). The gain stability of 45 of the array's LP Type II amplifiers is being determined from these gain measurement data. The standard deviation of the gain data collected since December 1970 is the measure being studied to determine the expected stability performance of the amplifier as operated in the present LASA CTH environment. To date, the gain standard deviations show a median value of 540 and a mean value of 570.

Since the seismometer data coil generator constants vary somewhat across the array, the channel amplification must vary among the amplifiers to provide the desired seismograph channel sensitivity standardization. The mean gains of the 45 amplifiers vary from 8,680 to 15,630. Summarized in Table XVIII are the individual amplifier statistics for the 95-week period.

4.3 Surficial Noise Studies

Local noise sources studied this quarter included the train traffic near subarrays E3 and F3, the strip mine blasting for coal near Coalstrip, Montana, and the explosive testing near Fort Peck, Montana. An estimated six or seven trains pass just north of E3 each day. During the approximate 30 minutes required for each train to pass, the increase in high frequency noise level on the E3 sensors 82 and 86 prevents satisfactory picking of seismic activity from the Develocorder film recordings. Replacement of these sensors with ones more remote from the railroad is recommended to SAAC if possible. Of future interest with regard to train traffic is the start of construction of a railroad spur line to run nearby subarray F3. This line will transport coal from a new open strip mine scheduled to operate near subarray F3.

TABLE XVIII

LP TYPE II AMPLIFIER GAIN STATISTICS - DEC 70 THRU SEP 72

TYPE II AMPLIFIER CHANNEL	MEAN GAIN $\times 10^3$	GAIN STD. DEV $\times 10^3$	MAX. GAIN $\times 10^3$	MIN. GAIN $\times 10^3$	MAX. ΔGAIN $\times 10^3$
A0-V	15.63	0.8359	17.38	13.94	3.44
A0-N/S	11.99	0.6511	13.24	10.68	2.56
A0-E/W	12.48	0.5979	13.57	11.18	2.39
C3-V	12.92	0.6350	14.49	11.20	3.29
C3-N/S	13.35	0.5430	14.52	11.52	3.00
C3-E/W	12.45	0.6274	14.27	10.62	3.65
C4-V	12.62	0.4900	13.76	11.41	2.35
C4-N/S	11.71	0.5120	13.43	10.51	2.92
C4-E/W	11.76	0.7130	14.29	10.57	3.72
D1-V	9.40	0.3847	10.34	7.75	2.59
D1-N/S	8.80	0.3763	9.65	7.37	2.28
D1-E/W	8.68	0.4279	9.46	6.77	2.69
D2-V	13.29	0.8285	14.97	11.86	3.11
D2-N/S	12.61	0.7729	14.12	11.56	2.56
D2-E/W	9.44	0.5946	10.73	7.13	3.60
D3-V	15.57	0.6252	17.01	13.95	3.06
D3-N/S	14.87	0.6806	16.20	12.12	4.08
D3-E/W	14.23	0.6222	15.32	12.17	3.15
D4-V	13.34	0.6200	14.68	12.03	2.65
D4-N/S	11.54	0.4186	12.53	10.62	1.91
D4-E/W	11.49	0.5460	14.70	10.51	4.19
E1-V	11.08	0.8568	15.49	9.31	6.18

TABLE XVIII

LP TYPE II AMPLIFIER GAIN STATISTICS - DEC 70 THRU SEP 72 (CONCLUDED)

TYPE II AMPLIFIER CHANNEL	MEAN GAIN $\times 10^3$	GAIN STD. DEV $\times 10^3$	MAX. GAIN $\times 10^3$	MIN. GAIN $\times 10^3$	MAX. ΔGAIN $\times 10^3$
E1-N/S	10.68	0.4450	11.62	9.18	2.44
E1-E/W	14.37	0.6191	15.95	12.18	3.77
E2-V	13.24	0.4810	14.52	12.19	2.33
E2-N/S	11.40	0.3169	12.13	10.57	1.57
E2-E/W	11.90	0.4745	13.20	10.90	2.30
E3-V	11.75	0.5410	12.98	10.83	2.15
E3-N/S	11.38	0.4015	12.40	10.66	1.74
E3-E/W	11.86	0.5051	12.85	10.90	1.95
E4-V	12.96	0.6216	14.27	11.01	3.26
E4-N/S	12.51	0.4351	13.43	11.29	2.14
E4-E/W	12.00	0.5290	14.54	11.01	3.53
F1-V	12.92	1.0177	14.33	9.27	5.06
F1-N/S	12.10	0.3980	13.11	11.39	1.72
F1-E/W	14.52	1.1655	18.71	12.25	6.46
F2-V	15.35	0.7307	16.71	12.00	4.71
F2-N/S	10.69	0.4390	11.42	9.63	1.79
F2-E/W	12.52	0.3805	13.90	11.67	2.23
F3-V	11.29	0.3578	12.38	10.47	1.91
F3-N/S	11.11	0.3329	12.04	10.42	1.62
F3-E/W	13.18	0.5724	14.12	9.87	4.25
F4-V	11.83	0.5801	14.92	10.57	4.35
F4-N/S	10.49	0.3820	11.34	9.63	1.71
F4-E/W	12.89	0.5795	14.49	11.24	3.25

Information has been collected from the strip mines presently operating near the array. At least two mines, whose coordinates have been coarsely determined, are blasting at regular intervals.

Explosive blasts were recorded from a series of tests conducted near Fort Peck, Montana. The availability of information, including the location, time, size and depth of each blast has helped in the preliminary determination of travel-time curves for the local and near regional seismic activity.

4.4 Failure Report

The array system and equipment failures which occurred and/or were corrected are reported in this section. All the failures are classified according to the type of failure and include these five classifications:

(1) System failure - A failure resulting in zero or no system output which prevents the system or equipment assembly from performing its primary function and identified as a Type 1 failure.

(2) Mode failure - A failure resulting in a zero or no system output only during one of several different modes of operation; a Type 2 failure.

(3) Limited failure - A failure resulting in a system output which is outside the allowable tolerance limits but permits degraded performance; a Type 3 failure.

(4) Latent failure - A failure which changes a system output either by an amount less than the allowable tolerance or from the nominal output when no tolerance limits have been established; a Type 4 failure.

(5) Temporary failure - A failure produced by an operating or environmental stress which results in no permanent physical damage; a Type 5 failure.

The number of failures detected and corrected in each of the ten Montana array systems is shown in Table XIX. The backlog of system or operating unit failures has decreased from 30 to 11. The SP subarray rehabilation activity in correcting SP sensor failures is the prime reason for this decrease. The SP sensor, PDP-7 computer, and the LDC Test and Support systems continue to be the chief contributions of system failures.

TABLE XIX

LASA SYSTEM FAILURE DETECTIONS AND CORRECTIONS

SEPTEMBER - NOVEMBER 1972

	STARTING BACKLOG	DETECTED	CORRECTED	ENDING BACKLOG
SP SENSOR	19	68	82	5
LP SENSOR	0	5	4	1
METEOROLOGICAL SYSTEM	0	0	0	0
SEM	0	13	11	2
POWER SYSTEM	1	3	4	0
360 COMPUTER	0	2	2	0
PDP-7 COMPUTER	7	42	47	2
LDC DIGITAL	0	2	2	0
LDC ANALOG	1	7	8	0
LDC TEST AND SUPPORT	2	18	19	1
TOTALS	30	160	179	11

The distribution of the equipment failures resulting from the system failures is shown in Table XX. Since more than one equipment failure may sometimes occur with a system failure, the number of equipment failures corrected may exceed the number of system failures reported.

Equipment failure rates for the array equipment have been determined for the period beginning May 1968. These average monthly failure rates have been totalled to determine a significant parameter for planning purposes, the system failure rate. Table XXI compares these average failure rates calculated since the beginning of this contract period (December 1971) with the historical rate. Summing the rates of the ten systems shows the average monthly failure rate for all of the array's equipment to be 47.69 failures/month; the figure for the contract period only is 47.93. These rates are remarkably close even though the distribution of the rates for the systems varies considerably.

TABLE XX

EQUIPMENT FAILURES

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
Short-Period System						
Seismometer	2	0	16	0	0	18
WHV Panel W/RA-5	8	0	43	6	3	60
RA-5 Power Supply	0	0	0	0	0	0
WHV Junction Box	0	0	0	0	0	0
WHV/Cables	1	0	0	0	0	1
CTH Junction Box (SP)	0	0	2	3	0	5
Total	11	0	61	9	3	84
Long-Period System						
Vertical Seismometer/Tank	0	0	0	0	0	0
Horizontal Seismometer/Tank	0	0	0	0	0	0
LP Vault/Cabling	0	0	0	0	0	0
LP Junction Assembly	0	0	0	0	0	0
Motor Assembly	0	0	0	0	0	0
Seismic Amplifier, Type II	0	0	3	0	0	3
Amplifier Power Supply	0	0	0	0	0	0
CTH Junction Box (LP)	0	0	0	0	0	0
Total	0	0	3	0	0	3
Meteorological System						
Aerovane, Wind Direction	0	0	0	0	0	0
Aerovane, Wind Speed	0	0	0	0	0	0
Pole Assembly	0	0	0	0	0	0
Pole Junction Box/Cabling	0	0	0	0	0	0
Temperature Probe	0	0	0	0	0	0
Electrobarometer/Baffle	0	0	0	0	0	0
Rain Gauge	0	0	0	0	0	0
Rain Gauge Electronics Panel	0	0	0	0	0	0
Total	0	0	0	0	0	0

TABLE XX

EQUIPMENT FAILURES (CONTINUED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					TOTAL
	1	2	3	4	5	
Subarray Electronics Modules						
Input Drawer #1	0	0	1	0	1	2
Input Drawer #2	0	0	1	0	0	1
Multiplexer/ADC	0	0	0	0	0	0
Output Drawer	2	0	2	0	0	4
PDC Drawer	0	0	4	0	0	4
ACC Cabinet	0	0	0	0	0	0
SEM Cabinet/Cabling	0	0	0	0	0	0
Alarms	0	0	0	0	0	0
Total	2	0	8	0	1	11
Power System						
Control Drawer	0	0	2	0	0	2
Inverter	1	0	2	0	0	3
Charger	0	0	0	0	0	0
Battery	0	0	0	0	0	0
SOLA Transformer	0	0	0	0	0	0
Rack Cabling	0	0	0	0	0	0
Isolation Transformer	0	0	0	0	0	0
Breaker Panel	0	0	0	0	0	0
Vault/Wiring/Breakers/Outlets	0	0	0	0	0	0
Total	1	0	4	0	0	5

TABLE XX

EQUIPMENT FAILURES (CONTINUED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					
	1	2	3	4	5	TOTAL
360 System						
CPU 2044	0	0	0	0	0	0
Disc Drive 2315	0	0	0	0	0	0
Typewriter 1052	2	0	0	0	0	2
Card Reader 2501	0	0	0	0	0	0
Data Control 1826	0	0	0	0	0	0
Data Adapter 1827	0	0	0	0	0	0
Data Adapter 2701	2	0	0	0	0	2
Total	4	0	0	0	0	4
PDP-7 System						
Computer	2	0	3	0	2	7
Teletypewriter KSR-35	1	0	1	0	0	2
Card Reader	0	0	4	0	1	5
SOU	0	0	0	0	0	0
Interface	0	0	0	0	0	0
Tape Unit #19	0	0	4	0	0	4
Tape Unit #32	1	0	5	0	2	8
Tape Unit #33	2	0	9	0	0	11
Tape Unit #22	3	0	3	0	3	9
Incremental Recorder	0	0	0	0	0	0
Total	9	0	29	0	8	46
Digital System						
Timing System #1	0	0	1	0	0	1
Timing System #2	0	0	0	0	0	0
Digital Data Simulator	0	0	0	0	0	0
Power System	1	0	0	0	0	1
PLINS	0	0	0	0	0	0
MINS	0	0	0	0	0	0
Total	1	0	1	0	0	2

TABLE XX

EQUIPMENT FAILURES (CONCLUDED)

ARRAY SYSTEM/EQUIPMENT	NUMBER OF FAILURES					
	TYPE OF FAILURE					TOTAL
	1	2	3	4	5	
Analog System						
D/A Patch Panel Cabinet	0	0	0	0	0	0
D/A Converter #1	0	0	0	0	0	0
D/A Converter #2	0	0	0	0	0	0
D/A Converter #3	0	0	0	0	0	0
D/A Converter #4	0	0	0	0	0	0
FM System	0	0	0	0	0	0
16 Channel Chart Recorder	0	0	0	0	0	0
WWV Receiver	0	0	0	0	0	0
Analog Calibration System	0	0	0	0	0	0
Analog Timing System	0	0	0	0	0	0
SP Develocorder	0	0	0	1	0	1
LP Develocorder	1	3	1	0	2	7
Total	1	3	1	1	2	8
LDC Test and Support System						
MDC-1	0	0	12	1	0	13
MDC-2	0	0	8	0	0	8
Clocks	0	0	0	0	0	0
Film Viewer	0	0	0	0	0	0
Film Duplicator	0	0	0	0	0	0
Copier	0	0	0	0	0	0
Emergency Lights	0	0	0	0	0	0
Compressor, Blower	0	0	0	0	0	0
Digital Clocks	0	0	0	0	0	0
Air Conditioners	0	0	0	0	0	0
Humidifier	0	0	0	0	0	0
Tape Cleaner	0	0	0	0	0	0
Electrostatic Filters	0	0	0	0	0	0
Total	0	0	20	1	0	21

TABLE XXI

EQUIPMENT FAILURE RATES

ARRAY SYSTEM/EQUIPMENT	MONTHLY FAILURE RATES SINCE 12/71	SINCE 5/68
Short-Period System	17.92	15.91
Seismometer	4.00	1.25
WHV Panel W/RA-5	13.08	14.00
RA-5 Power Supply	0.33	0.25
WHV Junction Box	0.00	0.09
WHV/Cables	0.09	0.15
CTH Junction Box (SP)	0.42	0.17
Long-Period System	1.33	2.70 (1)
Vertical Seismometer/Tank	0.00	0.65
Horizontal Seismometer/Tank	0.25	0.13
LP Vault/Cabling	0.00	0.19
LP Junction Assembly	0.00	0.35
Motor Assembly	0.33	0.29
Seismic Amplifier, Type II	0.67	0.81
Amplifier Power Supply	0.00	0.06
CTH Junction Box (LP)	0.08	0.26
Meteorological System	0.17	0.19
Aerovane, Wind Direction	0.00	0.06
Aerovane, Wind Speed	0.00	0.02
Pole Assembly	0.00	0.00
Pole Junction Box/Cabling	0.00	0.00
Temperature Probe	0.08	0.06
Electrobarometer/Baffle	0.00	0.00
Rain Gauge	0.00	0.00
Rain Gauge Electronics Panel	0.08	0.02
Subarray Electronics Modules	2.67	5.60
Input Drawer #1 Input Drawer #2	0.75	2.04
Multiplexer/ADC	0.08	0.43
Output Drawer	0.75	0.64
PDC Drawer	0.83	2.36
ACC Cabinet	0.25	0.11
SEM Cabinet/Cabling	0.00	0.02
Alarms	0.00	0.00

TABLE XXI

EQUIPMENT FAILURE RATES
(CONTINUED)

ARRAY SYSTEM/EQUIPMENT	MONTHLY FAILURE RATES SINCE 12/71	MONTHLY FAILURE RATES SINCE 5/68
Power System	1.67	1.40
Control Drawer	0.50	0.62
Inverter	1.17	0.58
Charger	0.00	0.15
Battery	0.00	0.00
SOLA Transformer	0.00	0.00
Rack Cabling	0.00	0.02
Isolation Transformer	0.00	0.00
Breaker Panel	0.00	0.00
Vault/Wiring/Breakers/Outlets	0.00	0.02
360 System	0.92	1.74
CPU 2044	0.08	0.77
Disc Drive 2315	0.00	0.00
Typewriter 1052	0.67	0.64
Card Reader 2501	0.00	0.13
Data Control 1826	0.00	0.00
Data Adapter 1827	0.00	0.06
Data Adapter 2701	0.17	0.13
PDP-7 System	13.00	12.72
Computer	1.50	1.11
Teletypewriter KSR-35	0.42	0.49
Card Reader	1.00	0.98
SOU	0.00	0.06
Interface	0.00	0.00
Tape Unit #19	1.58	
Tape Unit #32	3.17	
Tape Unit #33	3.00	8.15 (2)
Tape Unit #22	2.25	
Incremental Recorder	0.08	0.30
Digital System	1.00	0.51
Timing System #1	0.50	
Timing System #2	0.25	0.34
Digital Data Simulator	0.00	0.00
Power System	0.08	0.02
PLINS	0.08	0.08
MINS	0.08	0.08

TABLE XXI

EQUIPMENT FAILURE RATES
(CONDLUDED)

ARRAY SYSTEM/EQUIPMENT	MONTHLY FAILURE RATES SINCE 12/71	SINCE 5/68
Analog System	2.67	2.09
D/A Patch Panel Cabinet D/A Converter #1 D/A Converter #2 D/A Converter #3 D/A Converter #4	0.00	0.32
FM System	0.00	0 08 (3)
16 Channel Chart Recorder	0.17	0.54 (3)
WWV Receiver	0.00	0.17 (3)
Analog Calibration System	0.00	0.00 (3)
Analog Timing System	0.42	0.33 (3)
SP Develocorder	0.75	1.26
LP Develocorder	1.33	
LDC Test and Support System	6.58	4.83
MDC-1	4.08	4.62
MDC-2	2.17	
Clocks	0.00	0.00 (3)
Film Viewer	0.08	0.08 (3)
Film Duplicator	0.00	0.00 (3)
Copier	0.08	0.04 (3)
Emergency Lights	0.00	0.04 (3)
Compressor, Blower	0.00	0.08 (3)
Digital Clocks	0.00	0.04 (3)
Air Conditioners	0.08	0.13 (3)
Humidifier	0.00	0.00 (3)
Tape Cleaner	0.08	0.04 (3)
Electrostatic Filters	0.00	0.00 (3)

Notes: 1. Monthly failure rates since 5/70 and not 5/68.
2. Monthly failure rates since 7/69 and not 5/68.
3. Monthly failure rates since 12/70 and not 5/68.

SECTION V

IMPROVEMENTS AND MODIFICATIONS

5.1 General

Important to the operation of the Montana LASA is the continuing incorporation of improvements and modifications into the various equipments. These improvements permit increased efficiency in the utilization, operation and maintenance of the seismic observatory's systems. The improvements are categorized into these three areas, PDP-7 programming, array equipment and data center equipment. Improvements in the PDP-7 programming result in more efficient operation and increase the data collection capability of the array performance measurement activity. Modifications to the array and data center equipment are made to reduce the need for maintenance (i.e. improve reliability), to improve data quality, or to extend the operating capability.

5.2 System

5.2.1 SP Broadband Calibration System

A system for the measurement of the LASA SP seismographs amplitude vs frequency and phase vs frequency responses has been developed. This system is required at the LDC to provide a more comprehensive method of determining the complete response characteristics of the seismographs for insuring proper operation of the sensors as well as detecting equipment malfunctions.

The system utilizes pseudo-random bit sequences (PRBS) to generate a broadband signal (Ref. 5) which is used as an input to the array's seismometers. The PDP-7 computer at the LDC controls the PRBS using the array's telemetry system.

System operation consists of collecting the response data on PDP-7 digital tape recordings and then later processing on the PDP-7. Processing is accomplished with the array's normal seismic data off-line from the computer using the broadband analysis program BASP.

5.3 PDP-7 Programming

Programming effort for this period was concentrated on the broadband calibration analysis programs. BASP and BALP. Program BASP is described in paragraph 5.3.1.

5.3.1 BASP

Program BASP is used to provide broadband amplitude and phase calibration of the SP seismograph channels. BASP processes the seismograph output responses from the SP PRBS calibration

input. The program transforms the time series data into the frequency domain by computing the harmonic content at each sample time during the PRBS period. These harmonic components, collected from the 254 data samples, determine the amplitude and phase response of each seismograph channel. By comparing the responses from each channel to the input signal (as measured from the reference channel), the seismograph parameters of gain and phase for any selected harmonic of the fundamental frequency of the PRBS can be determined.

A sample output from program BASP is shown in Figure 5.1. The constant term or dc value of this Fourier series is printed first following the sensor identification and approximate calibration time. The frequencies (in hertz) commence with the fundamental, followed by the second harmonic, the third, and so on through the 76th harmonic. This frequency range encomposses the channel response range of interest. The gain values are in dB with respect to the reference signal and the phase in degrees.

The complete mathematical development and a detailed description of the program is scheduled to be written in the near future.

5.4 Array Equipment

5.4.1 SP Channel CTH Gain Control

Installation of the modification to provide a short-period sensor channel gain adjustment in the CTH (Ref 6) is now complete at all subarrays except E3. The installation schedule for the fourteen subarrays completed this quarterly period was as follows: A0-9/28, B1-10/17, B2-11/1, B3-11/10, B4-11/9, C1-10/11, C2-9/7, C3-9/5, C4-10/25, D1-10/24, D4-10/19, E1-9/11, F3-9/21 and F3-9/19. The E3 sensor channel instrumentation requires special consideration in completing the modification at this subarray; primarily due to lack of spare circuit cards.

To determine the best use of the modification in improving the SP sensor performance, the channel outputs from the standard sinusoidal calibrations are being adjusted according to two different procedures. In one procedure the sensor channel analog outputs are adjusted by an amount dependent upon the gain variation of the channel's seismic amplifier (RA-5). Future reports will indicate our progress in improving the SP channel gain characteristics from the present ±15% tolerance.

```
I HAVE THE FOLLOWING CALCULATIONS FOR SENSOR  D2  2345
FOR DATA RECORDED ON DAY 316 AT APROX 2100 HOURS.
```

```
DC VALUE FOR DATA SIG            -21.25196
SUM VALUE FOR DATA SIG        609958.00000
DC VALUE FOR REF SIG             -72.47244
SUM VALUE FOR REF SIG        1460436.00000
```

FREQUENCY	GAIN	PHASE
.07874	-45.00060	-148.37028
.15748	-27.02790	-110.67997
.23622	-21.61350	-83.11440
.31496	-18.75700	-81.70286
.39370	-16.44520	-61.66458
.47244	-14.99470	-52.66055
.55118	-13.45600	-38.94967
.62992	-12.19510	-32.86600
.70866	-11.54050	-17.82414
.78740	-10.87400	-8.60468
.86614	-10.29410	4.98702
.94488	-9.71470	16.40091
1.02362	-9.81430	26.46033
1.10236	-9.54820	36.13537
4.25196	-19.16790	-101.86845
4.33070	-19.34260	-88.30826
4.40944	-18.16790	-88.64115
4.48818	-18.65500	-83.10581
4.56692	-18.13640	-74.58535
4.64566	-20.40910	-72.66193
4.72440	-19.05590	-67.20336
4.80314	-19.24450	-64.68865
4.88188	-20.26660	-59.25243
4.96062	-20.79570	-48.15824
5.03937	-21.31350	-33.90706
5.11811	-21.56400	-26.17844
5.19685	-22.05740	-29.61275
5.27559	-22.08390	-23.55429
5.35433	-22.99100	-6.19653
5.43307	-24.32200	-.08708
5.51181	-24.93920	.30424
5.59055	-24.57430	10.00498
5.66929	-26.51230	14.72272
5.74803	-27.54180	11.46030
5.82677	-27.54960	23.12801
5.90551	-28.49690	40.59291
5.98425	-30.01690	25.51266

Figure 5.1 Program BASP Sample Printout

SECTION VI

MAINTENANCE

6.1 General

Maintenance activity at LASA includes correction of failures, preventive maintenance, modifications, special tests required for evaluations or quality control activities, facility and access maintenance, improvements, and vehicle maintenance. LASA maintenance activity is divided into three different categories: Data Center (LDC), Maintenance Center (LMC) and Facilities Support. The LDC in Billings covers the following five systems: the IBM 360/44 computer, the DEC PDP-7 computer, LDC Digital, LDC Analog, and the LDC Test and Support. The LMC located in Miles City maintains all array equipment systems which are comprised of SP Sensor, LP Sensor, Meteorological, SEM, and Power. Facilities Support provides maintenance of buildings, vehicles, land leases, and array facilities such as cable trenches, access trails, fences, WHV sites, and CTH sites.

6.1.1 Philosophy

During September to November weather and road conditions begin to limit travel to the sensor locations. During these months the field work on the SP sensor rehabilitation program is finished for the year and a concentrated effort to complete the CTH preventive maintenance routines at all subarrays is made. As long as field work is possible, shop work at the LMC is limited to preparing RA-5 amplifiers and HS-10-1/A seismometers for sensor replacements. When the inclement weather hits the previously deferred shop work, such as repair of printed circuit cards, begins.

6.1.2 Summary

Array maintenance completed by LMC included SP rehabilitation at four subarrays, installation of modification P-82 at 14 subarrays, preventive maintenance, repairs at selected WHV locations, and repair of RA-5 amplifiers. The LDC effort centered mainly on the PDP-7 system and preventive maintenance.

Table XXII summarizes the number of all equipment (LASA) and facility (utility) work orders completed this quarter. The 426 completed work orders represented 535 separate maintenance actions by technical personnel. The number and type of operational equipment failures corrected are discussed in paragraph 4.3. Work orders are used to document all LASA maintenance activities. The actual time or complexity required for a task is not indicated but the summary does indicate the type of work performed and the size of the work load. During the next quarter field activity will

TABLE XXII

WORK ORDER SUMMARY

SEPTEMBER 1972 - NOVEMBER 1972

WORK ORDER TYPE	BACKLOG START OF QTR	INITIATED	COMPLETED	BACKLOG END OF QTR
LASA:				
System - A	73	267	324	16
Subassembly - B	53	40	43	50
Component - C	44	52	27	69
Total	170	359	394	135
Utility:				
Cable trench & trail inspection	2	0	2	0
Cable trench backfill	1	0	1	0
WHV sites landscaped	0	3	3	0
Marker posts &/ or WHV covers replaced	0	8	8	0
CTH maintenance	0	10	9	1
Vehicle maintenance and inspection	0	6	6	0
Fence inspections	2	1	1	2
Trail repairs	2	0	2	0
Total	7	28	32	3
WORK ORDER TOTALS	177	387	426	138

be curtailed due to weather conditions and emphasis will be placed on shop work completing the B and C type work orders.

6.2 Data Center

6.2.1 System 360

Only one failure occurred in the IBM 360/44 system during the quarter. This failure in September on the 1052 typewriter was caused by a broken wire on the carriage return contacts. This wire carries the voltage for all contacts used to signal the CPU on typewriter functions. The wire broke due to the normal vibration of the unit.

6.2.2 System PDP-7

The PDP-7 system experienced major failures in September also. Previously, intermittant problems had occurred when using the tape drives and then two of the tape drives failed with very high parity errors. These compounded failures made trouble shooting very difficult. The intermittant problems were corrected by replacement of logic cards in the computer and adjustment of the tape controller section timing. Mechanical wear on all surfaces in contact with the tape was the cause of the TD-570 failures. Utilizing the new parts available and the salvaged parts on hand, the tape units were rebuilt. The main items replaced were capstan assemblies, arm and shaft assemblies (left) and block and solar cell assemblies. The deterioration of an erase head in one unit required replacement of the read-write head assembly. Read/write heads were exchanged in several units and both read and write skews adjusted to insure compatibility between units in regards to reading tapes written on other units.

Some of the mechanical assemblies mentioned in the previous paragraph still show signs of wear but the remaining salvage parts are no better. If further failures occur due to these assemblies, new parts will have to be obtained.

An intermittant failure in the Card Reader was resolved to be a shift in timing in the card feed circuit when the unit heated up. The problems disappeared when the covers were removed and were eliminated when the timing was re-adjusted when the circuit was warm.

6.2.3 Other LDC Equipment

One of the Develocorder units was overhauled and work started on the other one during this quarter. The plastic gravity feed hoses had hardened and developed leaks, and the metal front plate and partitions coming in contact with the solutions were badly deteriorated by chemical action. Since both units were overhauled about eighteen months ago, overhaul will be scheduled at twelve month intervals in the future to prevent operational failures.

6.3 Maintenance Center

The LMC maintenance efforts are divided into two activities: array tasks and shop testing and repairs.

6.3.1 Array Activities

There were 105 field trips covering 15,013 miles for the period and three trips were made to the PMEL at Great Falls to pick up and deliver test equipment for calibration.

The SP rehabilitation program was completed at subarrays B1, C1, C2, and C3 for a total of 14 subarrays of the 16 planned for this summer season. Since March 1970 when this program began, 70% of the 366 SP data channels have received maintenance attention. Subarrays B2 and B3 that were scheduled will be deferred till next summer as work schedules did not allow completion this summer. A number of individual WHV locations were visited for repair or replacement of the RA-5/panel to reduce the amount of array problems before the winter seasons limited travel. Replacement and/or adjustment was made for a total of 61 RA-5 amplifiers and 15 HS-10-1A seismometers.

The cables for leg 1 at subarray E3 were cut my machinery repairing a reservoir and were repaired by splicing and retrenching.

Table XXIII reflects the SP channel status as of November 30. The information in this table summarizes the outstanding conditions in the SP array requiring maintenance attention. This information is based on the five test criteria shown in the column headings. A total of 29 unsatisfactory test results are indicated, a decrease of 65% from the 82 reported last quarter.

6.3.2 Shop Activities

The main shop activities for this quarter were the modification of SEM control drawers and printed circuit cards for modification P-82, and repair of RA-5 amplifiers/panels in support of the SP rehabilitation program. There were 29 RA-5 amplifiers and two HS-10-1A seismometers repaired and tested. The deferred part B and C work orders will increase the shop activities during the next quarter.

6.4 Facilities Support

All subarrays have been inspected for damage and necessary land repairs have been completed. A total of 75 landowners were contacted regarding LASA operations and lease agreements.

Oil exploration drilling occurred at the following two locations in the array area:

TABLE XXIII

SP CHANNEL STATUS, 30 NOVEMBER 1972

SUBARRAY	CALIBRATION RESPONSE		NATURAL FREQUENCY		SENSITIVITY RESPONSE		SEISMIC EVENT POLARITY		SEISMIC EVENT AMPLITUDE	
	SAT.	UNSAT.	SAT.	UNSAT.	SAT.	UNSAT.	SAT.	UNSAT.	SAT.	UNSAT
AO	16	1	16	0	16	0	17	0	17	0
B1	17	0	16	0	16	0	17	0	17	0
B2	15	2	12	4	16	0	17	0	17	0
B3	17	0	14	2	15	1	17	0	17	0
B4	16	1	10	6	16	0	17	0	17	0
C1	16	0	15	0	15	0	16	0	16	0
C2	17	0	16	0	15	1	17	0	17	0
C3	16	1	14	2	15	1	17	0	17	0
C4	15	1	15	0	14	1	16	0	16	0
D1	17	0	16	0	16	0	17	0	17	0
D2	21	0	19	1	20	0	21	0	21	0
D3	17	0	16	0	16	0	17	0	17	0
D4	17	0	16	0	16	0	17	0	17	0
E1	17	0	16	0	16	0	17	0	17	0
E2	17	0	16	0	15	1	17	0	17	0
E3	25	0	25	0	25	0	25	0	25	0
E4	17	0	16	0	16	0	17	0	17	0
F1	16	1	15	1	16	0	17	0	17	0
F2	16	0	15	0	14	1	16	0	16	0
F3	17	0	16	0	16	0	17	0	17	0
F4	17	0	16	0	16	0	17	0	17	0
TOTAL	359	7	330	16	340	5	366	0	366	0

1. NENE Sec. 9-11N-38E. Less than 1 mile from sensor 74, subarray E4. Reported last quarter, drilled to 3,850 feet and now plugged and abandoned.

2. SESE Sec. 13-3N-41E approximately 9 miles from sensor 84, Subarray E3 and now plugged and abandoned.

No major surficial repairs were required this quarter. One cable trench was backfilled by hand and 12 WHV sites were landscaped to correct damage done by run-off and erosion. Fifteen minor discrepancies were corrected on various CTH vaults.

SECTION VII

ASSISTANCE PROVIDED TO OTHER AGENCIES

7.1 Seismic Data Laboratory

Develocorder film recordings of selected SP sensor data are made for SDL. Each film covers a period of approximately 24 hours; film change is made at about 2200 GMT. Ninety-two films with the format described in reference 7 were recorded during this period.

7.2 Weather Bureau

The Billings Weather Bureau office continued their request for periodic weather information from the outputs of the array's temperature, wind direction and speed, barometric pressure, and rainfall sensors. Three times each day a complete report of the latest available data are provided to them by the LDC operator.

7.3 Visitors

Visitors to the Montana LASA during the quarter were:

(a) Capt. Richard A. Jedlicka and Nils Maräs of NOR-SAR to tour array facilities and discuss array maintenance practices, on Sept. 11-14.

(b) Milton V. Richards, Philco-Ford C&TS headquarters staff, for indoctrination of seismic array programs on Sept. 18-19.

(c) Capt. John Fergus, VSC Montana LASA project officer, to inspect the array facilities Nov. 6-10.

SECTION VIII

DOCUMENTATION PROVIDED UNDER VT. 2708

8.1 Technical Reports/Letters

The following reports were distributed during this period:

(1) Montana LASA Third Quarterly Technical Report Project V/T 2708. T/R 2056-72-24, 15 Sept. 72.

(2) "Operation and Maintenance of LASA Monthly Progress Report" - September 1972 Report No. 2056-72-25.

(3) "Operation and Maintenance of LASA Monthly Progress Report" - October 1972 Report No. 2056-72-26.

(4) "LASA Requirements for Upgrading of Government Furnished Equipment," T/R 2056-72-27, Nov. 72.

8.2 Operations Data

Thirteen weekly issues of the Defective Signal Channel Status and Data Interruption Log Reports and Develocorder Operations Logs were distributed to approved using agencies.

8.3 Alternate Management Summary Reports

Three Alternate Management Summary Reports (AMSR) were prepared and distributed from Philco-Ford C&TS Division Headquarters; one for each of the months September, October and November 1972.

REFERENCES

1. Philco-Ford Corp. Montana LASA Second Quarterly Technical Report, ESD-TR-68-428 (AD 846 155) Billings, Mt., Nov. 68, Appendix A.

2. Philco-Ford Corp. Montana LASA Final Technical Report, Project V/T 1708, TR 2039-71-13 (AD 738 003) Billings, Mt., 22 Dec. 71, pp 33-35.

3. ibid., pp 127-131.

4. Philco-Ford Corp. Montana LASA Final Report, ESD-TR-69-283, (AD 860 480) Billings, Mt., July 69, pp 30-37.

5. Philco-Ford Corp. Montana LASA Second Quarterly Technical Report, Project V/T 2708, TR 2056-72-21 (AD 745 753) Billings, Mt., 15 June 72, pp 67-70.

6. Philco-Ford Corp. Montana LASA First Quarterly Technical Report, Project V/T 2708, TR 2056-72-16 (AD 742 488) Billings, Mt., 15 March 72, pp 54-61.

7. Philco-Ford Corp. Montana LASA High-Rate Data Table, Issue HR-47, Billings, Mt., 21 March 72.